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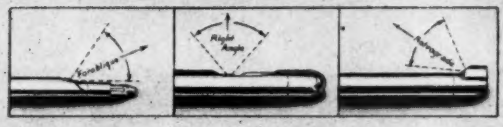


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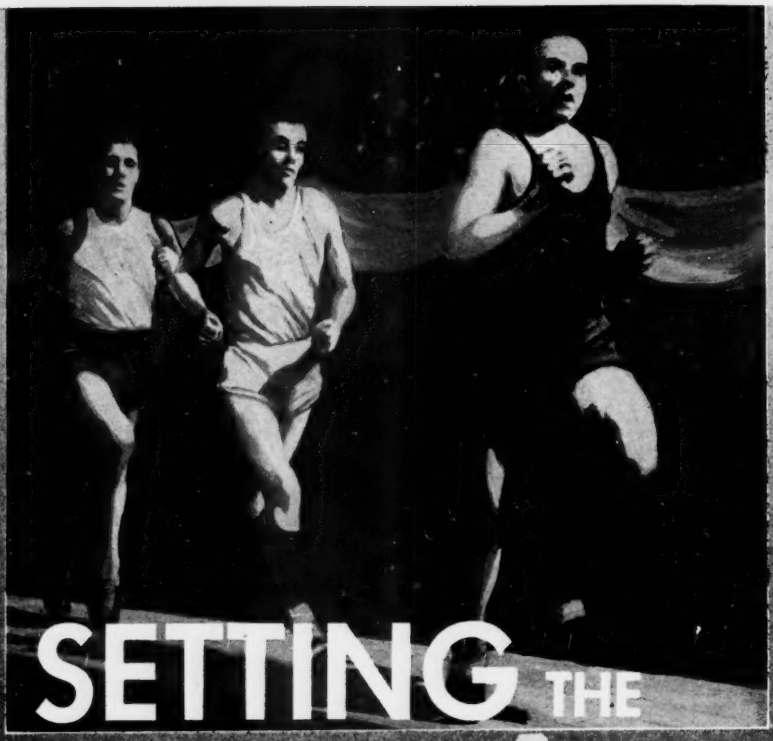

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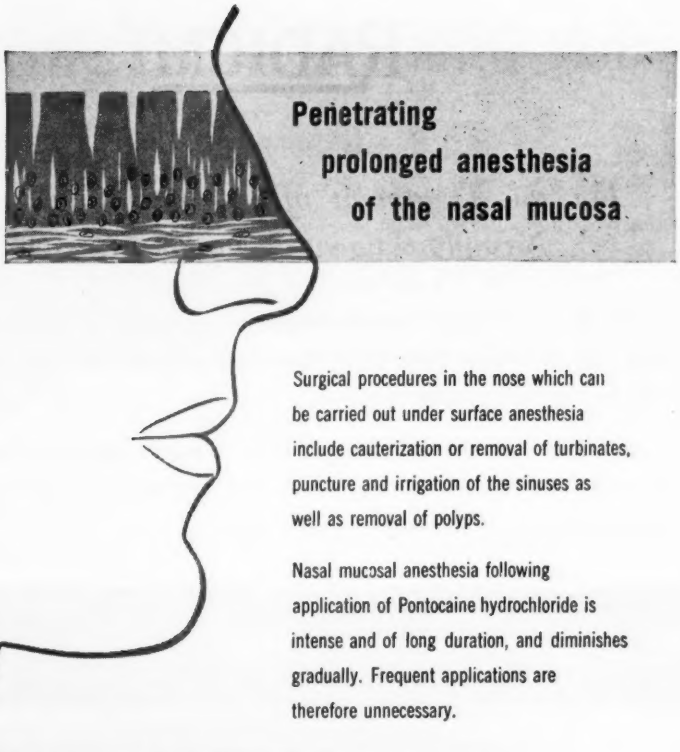

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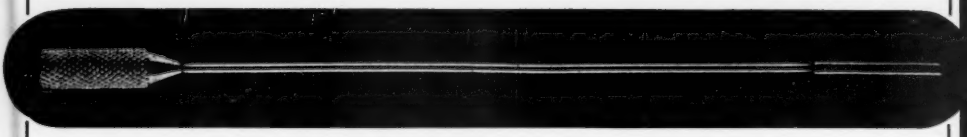

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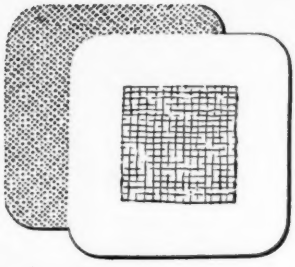

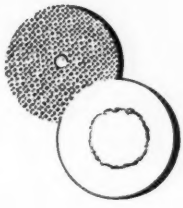

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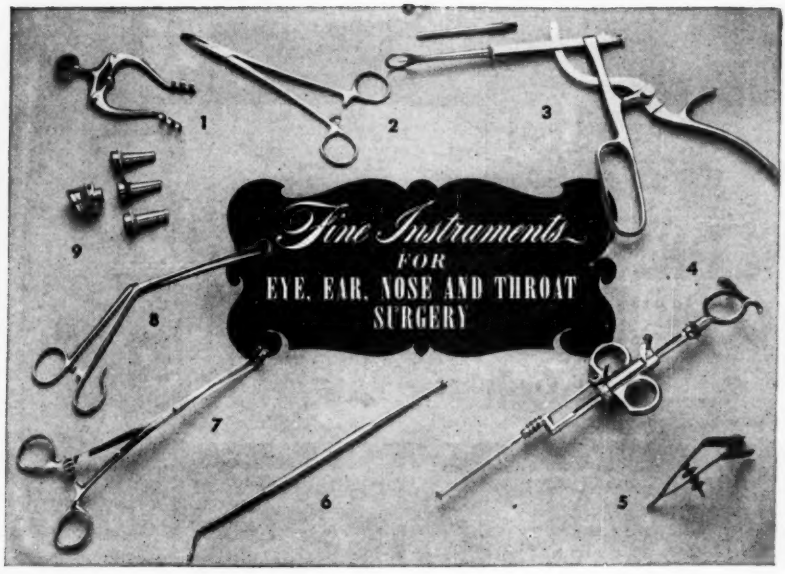


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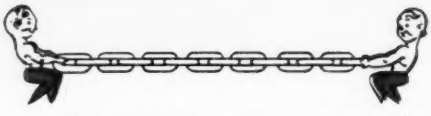

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# ROLE OF ALLERGY IN THE EPIDEMIOLOGY OF THE COMMON COLD

NOAH FOX, M.D.
AND
GEORGE LIVINGSTON, M.D.
CHICAGO

ALTHOUGH the virus is generally accepted as the causative organism of the common cold, much obscurity exists concerning the role of contributory factors, such as exposure to cold, fatigue and debility. These elements of one's environment have been much discussed in the literature, so that only a brief résumé will be necessary here. The purpose of this paper, however, is to suggest another factor, allergy, which will be discussed in relation to factors already known.

## THE CASE OF EXPOSURE TO COLD

Since time immemorial, chilling has been considered a factor in the pathogenesis of the common cold. The Germans express this thought in the term *Erkältung*. Certain investigators [1] had noted changes in the nasal mucosa of persons exposed to heat and cold, but none of these investigators produced laboratory evidence of these changes until Mudd and his associates [2] published their work. They then showed that cutaneous chilling causes a reflex sympathetic motor stimulation, resulting in depression of the temperature of the nasal mucosal surface through vasoconstriction and diminution of blood supply. They also recorded a number of colds and sore throats occurring among the subjects of the experiment. Ralston and Kerr [3] were unable to find any systemic differences between normal and hypersensitive patients as regards changes in nasal temperature in response to cold or hot

From the Department of Otology, Rhinology and Laryngology, University of Illinois College of Medicine.

1. Hill, L., and Muecke, F. F.: Colds in the Head and the Influence of Warm Confined Atmospheres on the Mucous Membranes of the Nose and Throat, Lancet **1**:1291, 1943. Schade, H.: Untersuchungen in der Erkältungsfrage, München. med. Wchnschr. **66**:1021, 1919; **67**:449, 1920.

2. Mudd, S.; Grant, S. B., and Goldman, A.: Reactions of the Nasal Cavity and Postnasal Space to Chilling of the Body Surface: I. Vasomotor Reactions, J. Exper. Med. **34**:11, 1921.

3. Ralston, H. J., and Kerr, W. J.: Vascular Responses of the Nasal Mucosa to Thermal Stimuli, with Some Observations on Skin Temperature, Am. J. Physiol. **144**:305, 1945.

stimuli, though Spiesman [4] reported that the very frequently infectious head cold presents a much delayed reaction to a cold stimulus. This and subsequent investigations of a similar character [5] comprise the experimental evidence that chilling plays a part in the genesis of the common cold. The mechanism thought to be involved is an altering of the local resistance by this chilling which allows the virus to multiply. However, no experimental evidence exists at this time to warrant the assumption that faulty function of the heat-regulating center of the body is responsible for susceptibility to infection of the upper respiratory tract. In no case in which investigators have succeeded in transferring the common cold to other persons or animals [6] has a chilling mechanism been involved, and, as a matter of fact, Powell and associates [6b, c] purposely carried out most of their experiments during the summer months.

Numerous studies have been made both in large population centers and in isolated communities to determine the relationship of weather and exposure to the common cold.[7] Except for some differences in the secondary invaders there is a close similarity of cases of the disease, whether it occurs in Greenland, Spitzbergen, Labrador, Alabama or in the Virgin Islands. Characteristically, all investigators reported similar observations, namely, complete freedom from colds, irrespective of the season, until some person made contact with the outside world and returned to the community with a cold.[7b, c] Characteristic, also, was the observation that once a cold occurred in these isolated communities which are normally free from colds, almost every person in the community acquired a cold, irrespective of the time of the year,

4. Spiesman, I. G.: An Experimental and Clinical Study of the Common Cold, Ann. Otol., Rhin. & Laryng. **50**:204, 1941.

5. Spiesman, I. G., and Arnold, L.: Host Susceptibility to Common Colds, Am. J. Digest. Dis. **4**:438, 1937. Ralston and Kerr.[8]

6. (*a*) Kruse, W.: Die Erreger von Husten und Schnupfen, München. med. Wchnschr. **61**:1547, 1914. (*b*) Powell, H. M., and Clowes, G. H. A.: Cultivation of the Virus of Common Cold and Its Inoculation in Human Subjects, Proc. Soc. Exper. Biol. & Med. **29**:332, 1931. (*c*) Dochez, A. R.; Shibley, G. S., and Mills, K. C.: Studies in Common Cold: IV. Experimental Transmission of Common Cold to Anthropoid Apes and Human Beings by Means of a Filtrable Agent, J. Exper. Med. **52**:701, 1930. (*d*) Powell, H. M.; Sparks, A. L., and Clowes, G. H. A.: Further Inoculation-Experiments with the Common Cold Virus, J. Immunol., **38**:309, 1940.

7. (*a*) Heinbecker, P., and Irvine-Jones, E. L. M.: Susceptibility of Eskimos to the Common Cold and Study of Their Natural Immunity to Diphtheria, Scarlet Fever and Bacterial Filtrates, J. Immunol. **15**:395, 1928. (*b*) Paul, J. H., and Freese, H. L.: Epidemiological and Bacteriological Study of the "Common Cold" in an Isolated Arctic Community (Spitzbergen), Am. J. Hyg. **17**:517, 1933. (*c*) Burky, E. L., and Smillie, W. G.: Nasopharyngeal Flora in Health and During Respiratory Disease in Isolated Communities in Alabama and Labrador, J. Exper. Med. **50**:643, 1929.

indicating almost a total lack of immunity, as one would expect under such circumstances. Yet it must be remembered that as fishermen these people are constantly exposed to cold and wet weather and are frequently immersed in cold water accidentally without suffering from colds.

Hill [8] stated:

> . . . In spite of popular opinion to the contrary it is clear that exposure even to extremes of cold, by itself, does not occasion "colds" or pneumonia. Shipwrecked folk, exposed almost to that point of chilling which stops the vital functions, do not suffer from coryza or pneumonia, neither do the troops exposed to the severest hardships in the trenches.

Smillie [9] concluded from his studies of colds in Alabama, Labrador and the Virgin Islands that in every instance epidemics of colds followed a drop in atmospheric temperature. He found mild colds in the tropics, where the weather is mild, and severe colds in the temperate zone, where the drop in temperature may be severe.

Brown and associates,[10] in a report of their analysis of the day to day changes in the incidence of the common cold in a group of 600 college girls during the year 1942-1943, concluded that heavy rainfall accompanied by dropping temperature definitely increased the incidence of colds in the college population. These investigators found that a group representing 23 per cent of the students had 45 per cent of the total number of colds. They appraised the students by means of a modified Flack test but were unable to find any uniform deterioration in fitness during the progress of the year to account for increased susceptibility to colds.

Sargent,[11] in observing the incidence of colds at Phillips Exeter Academy, noted that the passage of a cold front brought on within two to three days a rise in incidence of the common cold extending over the period of dropping temperature.

Duffield [12] reported a definite increase in the number of colds following the passage of a cold front, especially when this was associated with precipitation.

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8. Hill, L.: The Science of Ventilation and Open Air Treatment, Medical Research Council, Special Report Series, no. 52, London, His Majesty's Stationery Office, 1919, pt. 1, p. 141.

9. Smillie, W. G.: Observations on the Epidemiology of the Common Cold, New England J. Med. **223**:631, 1940.

10. Brown, W. B.; Mahoney, F.; Niedringhaus, A., and Locke, A.: Weather and Susceptibility in Relation to the Spread of Common Cold: Effect of Ascorbic Acid, in Massive Dosage, on Duration, J. Immunol. **50**:161, 1945.

11. Sargent, F.: Stability of Resistance to the Common Cold, Am. J. Hyg. **45**:29, 1947.

12. Duffield, T. J.: The Weather and the Common Cold, Am. J. Pub. Health. **19**:1, 1929.

Frost and Gover[13] reported on the incidence of colds from a large group of university students and families throughout the country. In spite of the wide dispersion of areas, there was a striking time correspondence in the cold epidemics of the years 1923 to 1926 and a uniformity of attack rate, indicating that climate is not an important epidemiologic factor.

### THE CASE OF FATIGUE AND DEBILITY

Locke[14] worked out an exercise technic imposing a stress which would just reach a severe overload when responded to at the maximal possible rate. He measured the rate of oxygen use during the final minute of measured effort which he considered as within the range of crest load for the normal person and overload for the undernormal person. Persons with heart disease or with any disease of the respiratory tract were rejected. The subjects were all school children. Locke expressed the belief that the efficiency of resistance is determined by the response of man to exercise.

The investigations were made through inquiry as to the number of colds incurred by these persons, who were then divided into two groups, one comprising those reporting one cold or less for the season and the other those reporting two or three colds. More than two thirds of the persons reporting one cold or less for the season had oxygenation times between 0.56 and 0.62; those reporting two or three colds times below 0.59. The grade of the subjects tested for oxygenation time on the day of onset of a cold was below 0.59 regardless of whether the grade had been above this mark previously. Locke pointed out this susceptibility as augmenting the shock-precipitating mechanism of a specific causal agent, such as the virus. He noted that 69 per cent of a mixed group of persons with fitness rated above 0.6 of maximal reported one cold or less for the winter of 1935-1936. Eighty per cent of an equivalent group of 15 persons with fitness rated below 0.5 reported four colds or more for the same period (1937). Locke found that the following nonspecific factors caused a lowering of resistance in rabbits and hence impairment of ability to resist infec-

13. Frost, W. H., and Gover, M.: The Incidence and Time Distribution of Common Colds in Several Groups Kept Under Continuous Observation, Pub. Health Rep. **47**:1815, 1932.

14. Locke, A.: Lack of Fitness as the Predisposing Factor in Infections of the Type Encountered in Pneumonia and in Common Cold, J. Infect. Dis. **60**:106, 1937; Non-Specific Factors in Resistance: I. Capacity to Sustain Effective Circulation, J. Immunol. **36**:159, 1939; IV. The Problem of Common Cold, ibid. **36**:365, 1939. Locke, A., and Main, E. R.: Non-Specific Factors in Resistance: II. Ability to Withstand Shock, ibid. **36**:173, 1939. Locke, A.: Non-Specific Factors in Resistance: V. Carbon Dioxide Tolerance, ibid. **36**:365, 1939.

tion: shock; exposure to overheating; deprivation of food; fatigue from chilling, i. e., shivering; circulatory failure from various causes, as drugs; shock injury; interference with oxygenation and water exchange; inanition, and endocrine deficiency. He concluded that fitness is a factor in resistance in that it "reflects adequacy of capacity for sustaining circulation which is essential for the efficient functioning of the defense mechanism."

Locke further developed a technic to measure the resistive efficiency of man, by having the subject inhale carbon dioxide for one to two minutes, which, he claimed, imposes a test emergency on the defense against suffocation, causing air increase in deep breathing. He worked out a ventilation quotient based on the ventilation rate, basal metabolic rate, and ventilation volume for a given number of respirations. He determined that a ventilation quotient of 1.29 may indicate a minimal predisposition to the common cold and that the susceptible person diverges from 1.29 more than 5 per cent.

Although Locke specifically stated that his results were obtained in patients free from allergy, we suspect that he means only frank allergies, i. e., asthma, seasonal and perennial allergic rhinitis, eczema, etc. He noted a tendency toward hyperreaction to inhaled carbon dioxide in a group of patients suffering from allergic dermatitis, a condition expected in the hypersensitive person, though this group did not have a heightened susceptibility to colds. On the other hand, the more usual type of hyperreaction to carbon dioxide was associated with heightened susceptibility to the common cold.

In a survey of 5,000 students an attempt was made by Smiley [15] to study the factors commonly associated with susceptibility to colds. These included effects of warm clothing, tobacco, rest, exercise, diet cold baths, constipation, heredity, etc. Of all the factors listed, he found that heredity might be important in determining resistance through carrying on to the next generation a catarrhal diathesis, or the opposite. He concluded that the major factor in susceptibility to colds is still a matter of conjecture but that there is an inclination toward the supposition that certain persons present a specific lack of immunity to the organism or organisms that cause colds.

Sargent,[16] in a four year study of the incidence of infections of the upper respiratory tract among Phillips-Exeter students, found a fixed incidence of colds each year for each student. He expressed the belief that some constitutional factor plays a significant role in deter-

15. Smiley, D. F.: Cold Susceptibles vs. Normals: Physique and Past Medical History, Am. J. Hyg. **9**:473, 1929.

16. Sargent, F., and others: Studies in the Meteorology of Upper Respiratory Infections, Bull. Am. Meteorol. Soc. **19**:385, 1938; **20**:141, 1940.

mining the incidence of colds and other infections of the upper respiratory tract.

### THE CASE OF ALLERGY

How is allergy related to these factors? It is common knowledge that allergic conditions are frequently initiated or exaggerated by a fall of temperature and increased humidity. The mechanism of this reaction is not clear but is thought to be related to increased permeability of the susceptible membrane, allowing the antigen to contact more readily its specific reagin in the cell.

Lurie [17] showed that resistance was associated with low cutaneous permeability as assayed by intradermal inoculation of india ink, increased rate and intensity of antibody response and development of a high degree of hypersensitivity.

There is a great deal of evidence that the common cold is an allergic response in susceptible persons to contact with a specific protein, which is the cold virus or its products.

Some of this evidence already exists in the literature, and some of it may be interpreted from reports which we quote.

Smiley,[18] in several surveys of college groups, came to the conclusion that most colds occur in a cold-susceptible group, the members of which present a history of more infectious disease, asthma and hay fever than normal students do.

Layton [19] noted that children frequently have cold after cold, winter after winter, for several years and then suddenly experience a cessation of this difficulty. He recalled that he was one of five children, two of whom, including himself, had frequent colds. He related that his colds ceased at the age of 12—a situation commonly seen in regard to allergic boys, about 50 per cent of whom lose the allergic tendency at puberty. He noted also that the other child, a sister who suffered from colds, suffered also from bronchitis, the entire picture suggesting an allergic background.

Coca,[20] in summarizing Locke's investigations, concluded that the latter's findings indicate that susceptibility to common cold is not due to a lack of the mechanism of defense but to a nonspecific impairment of the ability of the mechanism to function, resulting from a state of food sensitization. He found that 90 per cent of a group of 51 cold-susceptible persons were allergic to food. Of a group of 52 persons

17. Lurie, M. B.: Heredity, Constitution and Tuberculosis: Experimental Study, Am. Rev. Tuberc. (supp.) **44**:1, 1941.

18. Smiley, D. F.: A Study of the Acute Infections of the Throat and Respiratory System, J. A. M. A. **82**:540 (Feb. 16) 1924; footnote 15.

19. Layton, T. B.: The Common Cold, Practitioner **154**:65, 1945.

20. Coca, A. F.: Familial Nonreaginic Food Allergy as a Predisposing Cause of Common Cold, J. Lab. & Clin. Med. **26**:757, 1941.

who had no colds in the season studied, 31 had a family history of freedom from allergy to food, contrasted with 3 persons who had such a family history among the cold-susceptible group. Coca's explanation of the nonspecific factor of Locke is that it may be the effect of an allergic edema. He quoted Hoelzel,[21] McQuarrie[22] and Higgins,[23] who reported that the incidence of colds is reduced by restriction of carbohydrate consumption, the reduction being attributable to an observed lessening of tissue hydration.

Coca[20] added that there must be other predisposing causes of susceptibility besides allergy to food, because, although between 20 and 25 per cent of white families are free from such allergy, only 12 per cent are free from the common cold and a few of these are allergic to food.

Brown, Graham, Niedringhaus and Locke[24] made a study of 422 girls of Stephens College, Columbia, Mo., to evaluate the evidence reported by Coca for the existence of a cause and effect relationship between nonreaginic food allergy and the predisposition toward cold. They found that in 79 per cent of the group studied two or more of Coca's symptomatic evidences were present. They found a higher incidence of colds with an increasing number of symptoms.

Brown and Locke[24a] studied a group of women at Stephens College to determine the relationship of food allergy to colds. They noted particularly the relation of Coca's indicated allergic symptoms. Each of the eleven symptoms was associated, on the average, with a larger number of colds than was observed in the absence of symptoms. Furthermore, the number of colds increased directly and progressively with the number of symptoms present. That is, the greater the probability found for the presence of an underlying food allergy, the greater was the extent of predisposition toward common cold. One hundred and sixty-three of the students did not smoke and were in sufficiently good condition to pass the Flack fitness test. Of these, 36 had less than two of the accessory symptoms of nonreaginic food allergy, while 45 had four or more. The group with less than two symptoms had an average of 0.9 colds per person for the 1941-1942 season. The

21. Hoelzel, F.: Nutritional Edema and Its Relation to the Incidence of Common Colds, Proc. Soc. Exper. Biol. & Med. **25**:454, 1928.

22. McQuarrie, I.: Protein Metabolism of Children on Diets Extremely Low in Carbohydrates, J. Nutrition **2**:31, 1929.

23. Higgins, H. L.: Some Physiological and Clinical Effects of High Fat Feeding, New England J. Med. **203**:145, 1930.

24. Brown, W. B.; Graham, I.; Niedringhaus, A., and Locke, A.: Non-Specific Factors in Resistance: VI. Incidence of Common Cold in Persons With and Without Accessory Symptomatology of Nonreaginic Food-Allergy, J. Immunol. **46**:101, 1943.

24a. Brown, W. B., and Locke, A. P.: Fitness, Food Allergy and Predisposition to Common Cold, J. Missouri M. A. **40**:99, 1943.

contrasted group had an average of 1.8. One hundred and one of the nonsmokers failed to pass the fitness test. Of these, the 17 with less than two symptoms had an average cold incidence of 1.4. The 30 with four symptoms or more had an average of 2.8.

The poor ability to maintain effective circulation and to withstand the effects of a sudden fall of temperature exhibited by the cold-susceptible patient is in keeping with the physical allergy so often noticed in allergic patients.

When Duke [25] first reported physical allergy, he believed this condition to be present only in people who were free of atopic allergy. However, further study of this condition has proved that observation to be false. Swineford [26] found in a study of 325 persons with atopic allergy that physical allergy was the chief or the aggravating cause in 201. Vaughan's [27] experience confirms this conclusion. In short, two thirds of all persons suffering from atopic allergies are senistive to physical agents, as heat, cold and effort. Duke found early in his testing that, following the production of an allergic attack either with heat or cold, the patients were likely to contract an acute infection of the upper respiratory tract unless the reaction was promptly controlled by the application of the opposite thermal stimulus, and he expressed the belief that the tendency to repeated head colds or even pneumonia with change of season may be associated with allergy to heat or cold.

Bray [28] has shown that histamine is liberated in the skin of normal people when the temperature of the skin is decreased 20 F. In a case of cold allergy he found this threshold for the liberation of histamine raised 25 F.

The popular belief is that the common cold is initiated by chilling of the body, wetting of the feet or wearing of damp clothes. The response of the physically allergic person to these environmental factors may very well result in an outpouring of histamine into various shock centers throughout the body, particularly the respiratory tract, in sufficient quantity to destroy the local defense mechanism, preparing these tissues for acceptance of the virus of the common cold. Of course, the virus must be present. It is rather probable, however, that if such is the mechanism, secondary invaders will just as likely be

25. Duke, W. W.: Urticaria Caused Specifically by the Action of Physical Agents (Light, Cold, Heat, Freezing, Burns, Mechanical Irritation and Physical and Mental Exertion), J. A. M. A. **83**:3 (July 5) 1924; Physical Allergy: Preliminary Report, ibid. **84**:736 (March 7) 1925.

26. Swineford, O., Jr.: Physical Allergy: Its Role as Manifested in the Routine Study of Three Hundred and Twenty-Five Consecutive Allergic Cases, J. Allergy **6**:175, 1935.

27. Vaughan, W. T.: Practice of Allergy, St. Louis, C. V. Mosby Company, 1939.

28. Bray, G. W.: A Case of Physical Allergy, Brit. J. Child. Dis. **32**:45, 1935.

activated. One does not frequently see colds in people suffering from seasonable hay fever, presumably because the virus is not abundant at this season. There must be another factor which causes a person to be susceptible, irrespective of the condition of the nasal mucosa, and this factor must be tied up with the specific defense mechanism of the body. In Spitzbergen, Greenland, Labrador and other places of observation, contact with the virus caused colds in 100 per cent of the members of the community. This is similar to the observations made on apes by Dochez and co-workers.[6c] Dochez, in his animal experiments with colds, came to the conclusion that because chimpanzees could be reinfected as early as four weeks after recovery from a cold, immunity is nonexistent. The chimpanzee entirely lacks immunity because in his natural environment he is not exposed to colds. None of these persons or animals have nasal disease but lack immunity to this organism because of lack of previous contact. In short, an antigen-reagin relationship is suggested which can be accounted for only by assuming that an individual's susceptibility to colds is predicated on that individual's allergy to a particular protein, which is the cold virus or material elaborated by this organism. Obviously, where continuous infections take place, as they do in crowded communities, a person becomes less susceptible as he acquires more immunity through booster doses of antibody following mild infections, until a situation arises wherein some members of the community have none or only a few colds each year. This is in accord with general principles of allergy and immunity.

As with any allergic condition, a normal must be accepted. Given a concentrated enough antigen, all persons can be made to react in an allergic manner, for the allergic response is one derived from quantity rather than quality. It is easier to consider the cold-susceptible person as one who is allergic to a specific antigen (protein), which in his case is a virus.

As Vaughan [27] has suggested, everybody is allergic to some degree. The amount of allergy one develops depends on certain known factors, namely, the hereditary predisposition, the temporary permeability of the invaded tissue (which presumably may be influenced by fatigue, chilling, trauma, endocrine "let down," undernourishment, etc.) and, finally, by the frequency with which one comes in contact with a particular protein. A person is sensitized more easily to a foreign protein with which he establishes only occasional contact than to one with which the contact is constant. The specific sensitivity may be due directly to the virus or to some substance elaborated by the virus, such as, perhaps, the Duran-Reynals factor,[29] which increases the

29. Duran-Reynals, F.: Tissue Permeability and the Spreading Factor in Infection: Contribution to Host; Parasite Problem, Bact. Rev. **6**:197, 1942.

permeability of the respiratory membrane for invasion of the virus. The activity of the Duran-Reynals factor appears to be antigenic in that it is neutralized by antiserums.

That no specific allergic antibodies are demonstrable in the blood of the cold-susceptible person or that passive transfer has been a failure is due to lack of precise methods by which to demonstrate these phenomena. No bacterial or infective allergy has ever been demonstrated as atopic. The evidence for allergy as a factor in colds rests on the finding that people susceptible to colds have other allergies and come from families in which allergies are present. In 1940 we [30] published under the title "Borderline Allergy" our concept of allergy as a pathogenic factor of common colds. This concept was based on a study of 1,200 cold-susceptible persons. Eighty per cent of these persons mentioned other allergies, present or past, or came from allergic families.

*Summary of Data Indicating Allergic Background of 3,140 Persons Subject to Common Cold*

| Source | Total Number of Patients | Number with History of Other Clinical or Subclinical Allergies | Number with no History of Allergy But from Allergic Family | Number with no Personal or Family History of Allergy | Number with Hyperplastic Disease of Upper Respiratory Tract |
|---|---|---|---|---|---|
| University of Illinois Adults and children..... | 600 | 366—61% | 144—24% | 90—15% | 600—100% |
| Children's Memorial Hospital Children only..... | 140 | 81—58% | 31—22% | 28—20% | 140—100% |
| Private Practice Adults and children..... | 2,400 | 1,680—70% | 480—20% | 240—10% | 2,400—100% |

This number has now been increased to over 3,000, representing persons of all ages and walks of life.

Our problem has been primarily that of immunizing cold-susceptible persons with a virus vaccine, and it has been in the selection of these subjects that the epidemiologic phase of this work has developed.

The table represents an attempt to group the patients on the basis of allergy of the patient, allergy of the family or both. It will be noted that statistics of private practice reveal a higher percentage of cold-susceptible persons to be allergic than do statistics of a dispensary. This is, of course, because more precise information can be obtained from persons of this stratum of society. The subjects in the Children's Memorial Hospital group have been under our observation continuously for the past five years. Among the 28 children classified as nonallergic in this group were a considerable number from whom satisfactory information could not be obtained. It is probable, therefore, that some

30. Fox, N.; Harned, J. W., and Peluse, S.: Borderline Allergy: Its Relation to Hyperplastic Disease of the Respiratory Tract, Arch. Otolaryng. **31**:502 (March) 1940.

of these were allergic. The University of Illinois group were principally adults. A slightly better history of allergy was obtained from them. Many of the private patients have been under our observation for periods as long as ten years, and during this time allergic diseases such as hay fever and urticaria have developed in those who previously had negative allergic histories. It should be noted further in the table that 100 per cent of the patients of all the groups have a common pathologic condition, namely, hyperplastic disease of the upper respiratory tract. Frequently allergy goes unnoticed because it is of the borderline or subclinical variety. The nose and the pharynx of the cold-susceptible patient must be examined to ascertain whether there are changes in the mucosal and lymphoid structures.

The most common pathologic change observed in the upper respiratory tracts of cold-susceptible people in temperate climates is hyperplasia of the aforementioned tissues of the upper respiratory tract, particularly along the airways of the nose, i.e., the middle and the inferior meatus. This may vary from mild thickening and deformity of the middle turbinate to the formation of large polypoid masses in these areas. Often the posterior tips of the lower turbinates are hyperplastic, revealing a mulberry or strawberry shape. In infants and children the lymphoid tissue throughout the pharynx and back of the tongue is greatly increased, and in adults it forms thickenings at the lateral edge of the pharynx opposite the posterior choanae and the back of the tongue. These people suffer constantly from postnasal drip and mouth breathing due to nasal intumescence, frequent sore throat from the postnasal drip, attacks of laryngitis, and stomatitis from mouth breathing. These symptoms are frequently bearable until during and following a cold, when they become annoying because so often secondary invaders cause an increase of infection and an exaggeration of the symptoms. The person with hyperplastic tissues highly susceptible to colds rarely has a cold lasting only four to five days. Almost invariably he gets a secondary infection of the sinuses lasting three to six weeks. Apparently, the mucosa must be injured specifically by the virus to cause these long colds. Surgical trauma of the nose of any of these same people, even though followed by the additional trauma of a pressure-producing pack, only rarely produces a secondary purulent pansinusitis such as is seen following a cold in highly susceptible persons. The mucous membranes of the allergic person seem always to harbor organisms, ready, when the proper stimulus occurs, to overgrow. In 1937 one of us (Dr. Fox) and Harned [31] reported the following experiment to prove the fallacy of the argument that oft-times the tissues of

31. Fox. N., and Harned, J. W.: Treatment of Asthmatic Patients in Otolaryngologic Practice, Arch. Otolaryng. **25**:393 (April) 1937.

allergic persons are sterile, a statement frequently seen in the literature. Small pieces of tissue collected from the antrums of 25 allergic patients were obtained aseptically at operation. Only those antral tissues were taken which had proved sterile on washing. One portion was cultured on artificial mediums, then fixed and stained by the Giemsa method, while another portion was implanted in the peritoneal cavity of a guinea pig under aseptic precautions. After forty-eight hours the implanted tissue was removed, cultured and then fixed, sectioned and stained by Giemsa's method. Of the 25 specimens implanted, all revealed large numbers of bacteria, the coccal organisms predominating. Of the 25 duplicate tissues not implanted, only 8 were shown to be infected with organisms from artificial mediums. The organisms identified were alpha, beta and gamma streptococci, Staphylococcus aureus, Staphylococcus albus, Friedländer's bacilli and diphtheroids. In terms of virulence, it seems quite likely that the power of invasion of the ordinary respiratory organisms is influenced by specific environmental factors, as was demonstrated by the excessive growth seen in the buried tissues. However, there is no evidence that any known factor promotes easier entry of the respiratory tissues. It appears rather that the respiratory tissues of certain persons who have other allergies show a particular sensitiveness to the virus protein, which results in a combination of this antigen with sessile receptors in the cells, with the production of histamine, resulting in increased permeability and, of course, optimum conditions for the overgrowth of secondary invaders. Troescher-Elam, Ancona and Kerr [32] have recently reported a concentration of a histamine-like material in nasal secretion during colds.

## SUMMARY

Although it is popularly believed that exposure to cold, humidity, fatigue and debility are associated with lowered resistance to the common cold, confirmatory laboratory data are still lacking. However, these same factors are known to influence severely the allergic state of a patient.

The great frequency of other allergies in the cold-susceptible person or in members of his family suggests a specific allergy to the virus or its proteins.

In searching for other allergies in the cold-susceptible patient, one must remember that the majority of such patients present the borderline or subclinical rather than the frank type of allergy.

841 East Sixty-Third Street (Dr. Fox).

185 North Wabash Avenue (Dr. Livingston).

32. Troescher-Elam, E.; Ancona, G., and Kerr, W. J.: Histamine-Like Substance Present in Nasal Secretions of Common Cold and Allergic Rhinitis, Am. J. Physiol. **144**:711, 1945.

# CONGENITAL CHOANAL ATRESIA

## A New Transpalatine Technic

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A RECENT review of the surgical technics employed to treat congenital choanal atresia reveals that the maintenance of the normal function of the nasal mucous membrane is frequently disregarded in attempted corrective procedures. The surgical approaches appear to be designed primarily to remove bony obstruction and to maintain an opening. To accomplish these results many and varied surgical procedures have been reported. A new technic having the preservation of nasal function as its chief objective is suggested.

Among the earliest workers to report successful alleviation of the bony obstruction was Emmert.[1] In 1851 he removed the occluding bone with a curved trocar. This method of treatment was soon followed by many others. Electrocautery, chemical cautery, drilling through the nostril, use of mallet and chisel and curettage of various sorts were all tried, with varying degrees of success. The formation of scar tissue usually resulted in late closure of the opening and necessitated repeated operation. Most of these intranasal technics were unsuccessful.

In the early part of the twentieth century a new step was added. After the occluding bone was removed, the posterior part of the vomer was rongeured away; thus a large cavity was formed anterior to and confluent with the nasopharynx. In spite of this added step, many openings so created eventually closed. In an effort to prevent these closures, electrocoagulation, skin grafts and foreign bodies were employed subsequent to the initial surgical intervention. The results were unpredictable and usually not entirely satisfactory.

In a further effort to improve the end results, Kazanjian [2] developed the technic of first performing a submucous resection, after which the

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1. Emmert, cited by Boyd, H. M. E.: Congenital Atresia of the Posterior Nares: Descriptions of Technics Used in Meeting the Operative Difficulties and Report of a Case, Arch. Otolaryng. **41**:261 (April) 1945.

2. Kazanjian, V. H.: Treatment of Congenital Atresia of the Choanae, Ann. Otol., Rhin. & Laryng. **51**:704, 1942.

vomer and the bony obstruction were removed. In his procedure the columella was divided close to the floor of the nose, and the dissection was then carried upward and backward so as to free the septal cartilage, intact. The bony septum, together with its mucous membrane and all the occluding bone, was next removed. The cartilaginous septum was restored to its usual position and sutured into place. The results were somewhat better.

Transpalatine approaches were not overlooked. As early as 1909 Brunk [3] described his use of a longitudinal incision made in the midline of the palate. The results were not good, however, as scar tissue soon filled the nasal opening.

In 1931 Blair [4] described removal of the major portion of the hard palate and the cartilaginous and bony septums. Working through this opening in the bone he was able to find and remove fibrous tissue lying between the nasal floor and the nasopharynx. The mucoperiosteum of the floor of the nose and that of the septum were then sutured together, forming a continuous passage into the nasopharynx. This was a tremendous step forward, in our opinion, for it represented an attempt to institute a normal mucous membrane passage in the nose. Conceivably, this procedure might permit the development of respiratory epithelium with cilia and thus normal functioning of the nose. Previously a fistulous tract lined with scar tissue, skin or scarified mucous membrane had been the ultimate goal of surgical treatment.

Since that time various incisions made through the palate have been tried. Representative of many were the tongue-shaped flap suggested by Steinzeug [5] and the central incision with upper and lower cross cuts used by Schweckendiek [6] and Rebelo Neto.[7] These incisions still caused excessive scarring, which resulted principally from the extensive dissection of the hard palate and the destruction of the nasal mucous membrane. The removal of the palatine bone opposite the occluding area only, reported by Ruddy,[8] was a definite improvement. In our opinion, however, excessive scar tissue results from the removal

3. Brunk, A.: A new Case of Unilateral Osseous Choanal Occlusion: An Operation Through the Palate, Ztschr. f. Ohrenh. **59**:221, 1909.

4. Blair, V. P.: Congenital Atresia or Obstruction of Air Passages, Ann. Otol., Rhin. & Laryng. **40**:1021, 1931.

5. Steinzeug, A.: Surgical Technique for Removal of Choanal Coalescences, Arch. f. Ohren-, Nasen- u. Kehlkopfh. **137**:364, 1933.

6. Schweckendiek, H.: Transpalatinal Therapy of Congenital Choanal Atresia, Ztschr. f. Hals-, Nasen- u. Ohrenh. **42**:367, 1937.

7. Rebelo Neto, J.: Transpalatine Route in Therapy of Bilateral Congenital Imperforation of Choanae, with Report of Cases, Rev. brasil. de oto-rino-laryng. **10**:431, 1942.

8. Ruddy, L. W.: Transpalatine Operation for Congenital Atresia of the Choanae in the Small Child or the Infant, Arch Otolaryng. **41**:432 (June) 1945.

of the posterior portion of the septum. Another advance was reported by Klaff,[9] who made an incision through the soft palate and opened the closed choanae with rasps under direct vision. The second step of his procedure is difficult to understand, however, because he removed the bony portion between the open nostrils at a later date.

The importance of ciliary action in nasal function, so forcefully demonstrated by Proetz,[10] makes it probable that the nose cannot function properly without it. The fistulous tracts produced by most of these operations are entirely without cilia.

A surgical method employing earlier technics and yet preserving functions of the nasal mucous membrane in keeping with the postulates of Proetz [10] is therefore suggested, whereby the bony obstruction is removed and the normal function of the nasal mucous membrane is maintained. Following is the report of a case of congenital choanal occlusion with a summary of the method used in treating it.

## REPORT OF A CASE

S. R., an 8 year old white girl, was admitted to the Salt Lake County General Hospital on May 13, 1946 with the complaints of (1) "obstruction of the left nostril since birth" and (2) "almost constant discharge from the left nostril since shortly after birth."

The infant was born spontaneously at term after uneventful labor. In the nursery she appeared normal, took all feedings well and gained weight. Shortly after the infant was discharged from the hospital, the mother noticed a watery fluid escaping from the nose. Believing that the infant had a "cold," she paid little attention to the difficulty. After a few weeks, however, the fluid was still observed, coming principally from the left side of the nose. The family physician prescribed nose drops. For short periods it was thought that the discharge had subsided somewhat, and the nose drops were used intermittently. It became apparent that the discharge was continuing in spite of the therapy, and other kinds of nose drops were tried. These treatments went on until the child was 3 years of age; then the physician decided to operate surgically "to permit drainage from the sinuses." This operation failed to alleviate the condition, and after a few months it was decided to remove the child's tonsils and adenoids. After their removal the parents believed the condition was improved, but it was not long until the discharge was as it had been before the operation.

At the age of 5 years the child began to experience occasional mild frontal headaches. These headaches were always accompanied by some dizziness and were relieved promptly by acetylsalicylic acid and short periods of rest in bed. At about this same time she experienced her first epistaxis. The bleeding usually came from the left nostril and was said to occur without trauma or apparent cause. However, the child was frequently seen placing a finger in her nostril, wiping away nasal discharge and rubbing the outside of the nose.

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9. Klaff, D. D.: Bilateral Congenital Atresia of the Choanae, Arch Otolaryng. **41**:298 (April) 1945.

10. Proetz, A.: Essays on the Applied Physiology of the Nose, St. Louis, Annals Publishing Company, 1941.

The child was unable to enjoy, and refused to perform, any actions which necessitated flexing the head on the neck. Soon after the head was placed in this position, fluid could be seen dripping freely from the left nostril. She did not want to play the piano, draw or color pictures or participate in activities which demanded that she bend the head forward for any length of time. In spite of this she remained relatively unaffected by the limitations imposed on her until she entered school. At that time she hesitated to participate in various activities because the nasal discharge drew comments from her schoolmates. Because of these remarks, she began to withdraw from groups and group activities. She began to be "nervous," and her appetite flagged. Nasal twitching and facial grimacing became much more noticeable, and occasional nocturnal enuresis occurred. Because of these developments and the fact that the nasal discharge was still present, the child was referred to a local pediatrician. An obstruction of the left side of the nose was discovered, and the child was referred to this hospital for treatment.

Other illnesses in the past had included "infrequent colds," "hay fever" in the month of May only, measles and chickenpox. The child had been immunized against diphtheria, pertussis and smallpox.

The family history was noncontributory.

At the time of admission the rectal temperature was 100.4 F., the pulse rate was 100 per minute and the respiratory rate was 20 per minute. The patient's height was 46 inches (117 cm.), her weight 56 pounds (25 Kg.), and the Wetzel grid [11] showed the patient to be $A_8$, 65 units, 67 per cent. The systolic blood pressure was 106 and the diastolic blood pressure 74. The child appeared neither acutely nor chronically ill or distressed. She was cooperative and pleasant and appeared fairly well nourished. During the interview and the physical examination she was seen occasionally to wipe away a thin, watery nasal fluid and to sniff and rub her nose more frequently. Except for a grade 1 soft blowing systolic murmur, heard best at the left sternal border, the positive findings of the physical examination were limited to the left side of the nose. The external contour of the nose was asymmetric in that the left naris was broader and wider than the right. The left ala nasi was thicker than the right, and the left side of the nose had a somewhat more flattened appearance. There was evidence of recent trauma (probably from finger nails) in the left vestibular area of the nose. The mucous membrane was pale pink and glistening. In the floor of the nose there was a pool of odorless gray mucoid discharge. The septum was straight and imperforate. The inferior turbinate appeared to enlarge posteriorly and was very firm to the touch. The right side of the nose appeared normal in all respects. When the child was asked to bend her head forward, fluid began to drip slowly from the left nostril. After the mouth and the right side of the nose were closed, the child was unable to force air either in or out through the other nostril. A probe placed in the left side of the nose met a definite, impassable obstruction at a depth of 3.0 cm. Iodized poppyseed oil 40 per cent was instilled into the left side of the nose, and roentgenograms were taken. Following is the interpretation of the films as reported by Dr. Henry H. Lerner, of the department of roentgenology of the University of Utah:

"Films taken after iodized oil had been instilled into the left naris showed complete obstruction of the posterior nasal airway. The iodized oil was distributed over the turbinates without any of it entering the pharynx."

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11. Wetzel, N. C.: Assessing the Physical Condition of Children, J. Pediat. **22**: 82, 208 and 329, 1943.

Repeated studies of the blood and the urine gave normal results. The Mantoux and Kahn tests were negative. Cultures of material taken from the nose revealed a mixed growth of streptococci, pneumococci and staphylococci.

On the fourth hospital day the patient was taken to the operating room. With the patient prone, intubation was carried out, and the head was lowered about 12 inches (30 cm.). The mouth was kept open with a Davis mouth gag. An incision of the hard palate was made parallel to, and ¼ inch (6.5 mm.) to the left of, the midline; it began at the border of the hard palate and extended ½ inch (12.5 mm.) anteriorly. The incision was carried through mucous membrane, muscles and periosteum. The periosteum was elevated laterally and retracted. A square of bone approximately the size of the obstruction was removed. We then took out

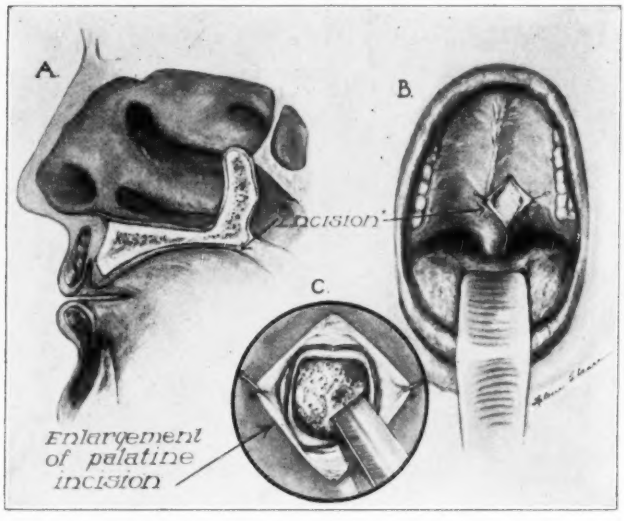


Fig. 1.—Steps by which the bony obstruction of the left nasal passage was removed.

as much of the obstructing bone as could be reached by gouge, chisel and punches, using a submucous resection technic from below. During this removal care was observed to attempt to leave intact the mucous membrane covering the bony obstruction. Except for a few minor tears this goal was accomplished. After the removal of the bone we had an empty shell of mucosa having a somewhat pyramidal shape, with the base overlying the hole in the hard palate. Through the nostril a single vertical incision was made through both walls of this membrane. Thus the anterior and posterior wall of this mound each became separated into two flaps which when loosened at the base simulated swing doors. On each side the anterior flap was moved laterally and posteriorly and the posterior flap was moved laterally and anteriorly. This formed a continuous lining along the sides of the nose, and the redundant tissue remained as a partial carpet for the floor of the nose. This lining was packed lightly in place with petrolatum gauze, and a

section of no. 20 catheter was placed inside the petrolatum gauze. A counter-incision made medial to the palatine artery and parallel to the operative incision permitted closure of the operative site without any tension on the suture. The patient was returned to the ward in good condition.

One hour after the completion of the operation the child was talking with her mother and had no complaints except that she was nauseated and her throat hurt. Fluids were administered intravenously for some ten hours, and then oral administration of fluids was started. After the operation the temperature rose to 101.2, and 20,000 units of penicillin was given every three hours. On the second postoperative day the temperature and the pulse rate dropped to normal and remained normal until the patient was discharged from the hospital. She began to take fluids orally freely on the second postoperative day. She was permitted to eat a soft diet

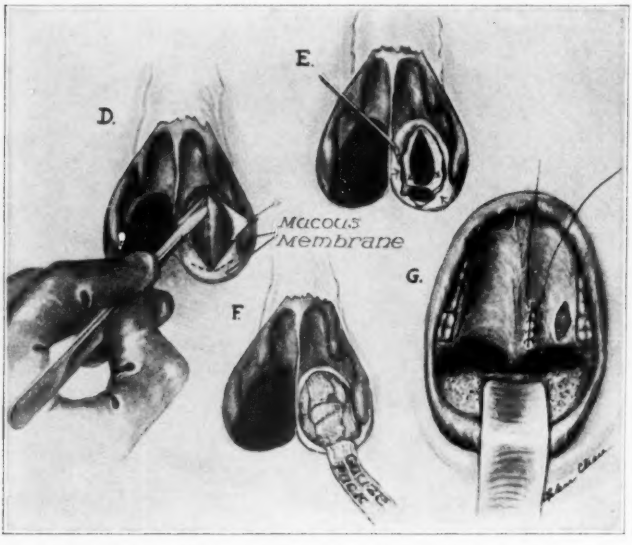


Fig. 2.—Steps by which the conserved ciliated mucous membrane was used to line the new nasal passage.

for twenty-four hours and a regular hospital diet thereafter. The nasal opening healed rapidly, and the child was able to breathe easily through the left side of the nose. She was discharged from the hospital eight days after admission and five days after operation. At the time of discharge a small amount of serosanguineous fluid was escaping at intervals from the left naris.

Two weeks later when the patient returned for a checkup accompanied, by her family, it was observed that the entire family had stuffy or running noses. The patient's nasal mucosa was greatly swollen, and a large crust was present over the incision. The crust was removed from the nose, and the patient instructed to return in two weeks. One month after the surgical procedure the child was able to breathe through a large opening in the left side of the nose. There was no discharge.

Four months after operation the patient again returned for examination. She was breathing comfortably through both nostrils. There was no discharge in her nose. Her weight had increased 8 pounds (3.6 Kg.) since the operation, and she had returned to school, where she was happy and doing well. She was no longer nervous, and there had been no further enuresis. The opening in the left side of the nose was about the size of a pencil. The patient was seen again thirteen months after operation. During this period she had had few "colds," and her nose had been comfortable at all times. She was able to breathe easily through both sides of the nose. An applicator passed easily into the nasopharynx through the opening, which had not decreased in size.

Although the period since surgical intervention has been over two and a half years, the results seem promising in that little scar tissue has formed. Ciliary action probably is present, for even with a "cold" occurring several weeks after the operation the nasal drip did not reappear.

The results observed in this case lend support to the theory that the successful treating of congenital choanal atresia depends less on the size of the opening made than on a continuous lining of functioning ciliary mucosa. It is possible that further studies may reveal new surgical approaches that will simplify the correction of this deformity.

Among the striking features of the case were the psychologic influence of this relatively minor physical defect on the child and the prompt improvement which followed the correction of the abnormality.

## SUMMARY

A review of the literature shows clearly that surgical repair of congenital choanal atresia has in the past rarely been successful. Failure has almost always been due to secondary scar formation which closes the opening, despite attempts to produce a permanent fistula by means of skin grafts, prostheses or repeated cauterizations. Even in those instances in which a permanent fistula has been made there has usually not been a return to normal nasal function, owing to the fact that no ciliated epithelium lined the new opening.

A new approach to this problem is described which permits the obstructing bone to be removed by a transpalatine technic and a new nasal passage to be formed which is lined with flaps of ciliated mucous membrane.

One case is reported in which this technic was used. The patient has experienced entire relief of her nasal complaints since the operation thirty-one months ago. The emotional and social readjustment following the alleviation of this minor defect was striking.

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# WHICH IS THE PREFERABLE METHOD OF PERFORMING THE CALORIC TEST?

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THE CALORIC test is one of the most used clinical methods of investigating the vestibular organ. The utility is evident, as it enables one to get information on the localization of a deviation not only in one labyrinth but even, as has been made probable of late, in the central nervous system. However, to be able to compare the results of different workers, the execution of the test has to be identical, and this it seldom is. Bárány,[1] though not the first to observe the reaction of the vestibular organ on caloric stimulation, an honor which belongs to Brown-Séquard [2] and Breuer,[3] was the first to see the clinical importance of this method and also the first to give a theory as to the origin of the reaction and a description of the phenomena which occur when an ear is syringed with cold or warm water—all this in such a way that hardly any essentially new data are registered in later work on this subject. But after him many observers, using as many different technics, studied the caloric sensitivity of the semicircular canal (Brünings [4]; Kobrak [5]; Fischer [6]; Hallpike [7]). The importance of the

From the University Clinic for Diseases of the Ear, Nose and Throat; Prof. Dr. A. A. J. van Egmond, director.

1. Bárány, R.: Untersuchungen über den vom Vestibularapparat des Ohres reflektorisch ausgelösten rhythmischen Nystagmus und seine Begleiterscheinungen, Monatsschr. f. Ohrenh. **40:** 193, 1906.

2. Brown-Séquard, C.: Course of Lectures on the Physiology and Pathology of the Central Nervous System, Philadelphia, Collins, 1860, p. 187.

3. Breuer, J.: Neue Versuche an den Ohrenbogengangen, Arch. f. d. ges. Physiol. **44:**135, 1889.

4. Brünings, H.: Beiträge zur Theorie, Methodik und Klinik der kalorimetrischen Funktionsprüfung des Bogengangsapparates, Ztschr. f. Ohrenh. **63:**20, 1911.

5. Kobrak, F.: Beiträge zum experimentellen Nystagmus, Beitr. z. Anat., Physiol., Path. u. Therap. d. Ohres. **10:**214, 1918; **11:**244, 1919; Zur Frage einer exakten Messbarkeit der Sensibilität des Vestibularapparates, Arch. F. Ohren, Nasen- u. Kehlkopfh. **105:**132, 1919-1920.

6. Fischer, M. H.: Grundsätze für die Normung der vestibulären Nystagmusprüfung, Klin. Wchnschr. **12:**1925, 1933.

7. Hallpike, C. S.: The Investigation of Ménière's Disease, J. Laryng. & Otol. **43:**349, 1943.

position of the head in the performance of the test (Brünings [4]), the necessity to avoid too intense stimuli (Kobrak [5]) and the desirability of proof of not only the frigoric but also the caloric excitability (de Kleyn [8]) are generally accepted nowadays.

Kobrak, however, stressed the importance of employing small quantities of water in executing the test, whereas Hallpike [7] has used a large quantity of water. Most investigators try to limit the fixation of the eyes with strong biconvex glasses, following the method of Bartels or Frenzel, a method rejected by Hallpike.

The position of the patient is not the same for every examiner; for instance, according to Brünings,[4] a fixed optimum position is prefered by many authors, but Fischer [6] syringes the ear in the zero position and turns the head backward one minute later.

In a great number of experiments on normal subjects I have tried to solve the question whether there is a method which actually surpasses others. In order to obtain an answer to this question I have tried variations in some minor parts of the technic of the caloric test.

The first question arising is: Which phenomenon caused by the thermic stimulation of the labyrinth lends itself best to being measured? The labyrinth, being a sense organ, produces sensations and reflexes in the same way as any other sense organ. While avoiding a thorough study of the theories concerning the origin of the phenomena produced by thermic stimulation, one may accept a stimulation of the vestibular nerve or of parts of it by the way of a stimulation of the peripheral organ without being too imprudent.

This stimulation causes a sensation of turning and (or) of change of the position of the body in space and an alteration of the tonus of groups of muscles throughout the body. The latter may be observed in the limbs—deviation in walking with eyes closed, deviation in the Romberg test *de fil à plomb* and deviation in the pointing tests according to Bárány and Quix and in the eyes (nystagmus). The nystagmus, however, is a more complex phenomenon consisting of a quick and a slow phase. The latter is the same as the variation of tonus in the entire musculature, while the quick phase is a specific property of the movements of the eyes, probably originating in the central nervous system (in general anesthesia the quick component of the nystagmus disappears, the slow component remains) (Quix [9]; Wodak [10]).

8. de Kleyn, A.: Détournements des differentes formes de nystagmus dans le système nerveux central, Versl. v. d. Nederl. Akad. v. Wetensch. **44**:268, 378 and 540, 1941.

9. Quix, F. H.: Les méthodes d'examen de l'organe vestibulaire, Paris, Vigot Frères, 1929.

10. Wodak, E.: Zur Physio-Pathologie des Vestibulärapparates, Pract. oto-rhino-laryng. **9**:30, 1947.

In the University Clinic for Diseases of the Ear, Nose and Throat my colleagues and I have learned to appreciate the usefulness of vestibular sensation in obtaining quantitative data on the function of the vestibular organ by performing the turning test with small regulable stimuli (in the same way as the sense of hearing is measured in audiometry) (van Egmond, Groen and Jongkees[11]). In the case of the caloric test, however, the sensation failed to give us valuable information. Many patients, even those who were used to self observation, had no turning sensation whatsoever; others needed strong stimuli to get a sensation. In most cases the sensation appeared long after the nystagmus and disappeared long before the nystagmus ceased.

This is in clear contradiction to the experiments of Fischer and Wodak,[12] which indicated that in the caloric test sensation is a much more sensitive basis for examination than nystagmus. They experimented only with themselves as test subjects, and their great training in self observation may explain these results, but for an investigation of clinical technics it is unserviceable.

The influence of the labyrinth on the muscle tone of the body, measurable in the walking test or the pointing test, is not suitable for a quantitative analysis. Therefore we are obliged, as has been done since the beginning of the clinical practice of the caloric test, to use the nystagmus as an indicator of the activity of the vestibular organ. As we always use the more perceptible quick phase, the activity of the vestibular organ is observed by the assistance of a reflex which is certainly of nonvestibular origin.

However, one may consider the nystagmus from different angles. Its properties suitable for measurement are strength, frequency, time of latency and duration. It is not easy to measure the strength of the nystagmus, which is not the same as the proportion of duration and frequency, and the many methods described in which such measurements have been made by registration of the nystagmus do not lend themselves to common clinical use (Wotzilka,[13] Ohm,[14] Kuilman[15] and Perlman and Case[16]).

11. van Egmond, A. A. J.; Groen, J. J., and Jongkees, L. B. W.: The Turning Test with Small Regulable Stimuli—I, J. Laryng. & Otol. **62**:63, 1948.

12. Fischer, M. H., and Wodak, E.: Experimentelle Untersuchungen über Vestibularisreaktionen, Ztschr. f. Hals-, Nasen- u. Ohrenh. **3**:198, 1922.

13. Wotzilka, G.: Ein neuer, klinisch verwendbarer Nystagmograph, Ztschr. f. Hals-, Nasen- Ohrenh. **8**:93, 1924.

14. Ohm. J.: Untersuchung des Augenzittern, in Alexander, G., and Marburg, O.: Handbuch der Neurologie des Ohres, Berlin, Urban & Schwarzenberg, 1924, vol. 1, p. 1098.

15. Kuilman, J.: Nystagmographie während der Drehung, Ztschr. f. Hals-, Nasen- u. Ohrenh. **35**:85, 1933.

16. Perlman, H. B., and Case, T. J.: Nystagmus: Some Observations Based on an Electrical Method for Recording Eye-Movements, Laryngoscope **49**:217, 1939.

In order that the results of various scientific workers may be compared, it is of paramount importance to give numbers and methods which can be easily imitated. Only in this way may so-called objective results be obtained. The strength of the nystagmus cannot yet be given in a number and is therefore not suitable for our purposes.

The frequency of the nystagmus is easily given in a number, but the result is not the same when the experiment is repeated under the same outer circumstances: The result is not reproducible, varying greatly in the same patient, as already been shown by Fischer [17] and Woletz.[18] I have the impression that it is possible in many instance to influence the frequency of the nystagmus by concentrating the patient's attention as well as by rubbing the cheek with alcohol or by other means (Hennebert [19]; Grahe [20]).

The third possible indicator of the caloric stimulation of the labyrinth, i.e., the time needed for the stimulus to cause the first quick phase of nystagmus, is judged differently. According to Cawthorne, Fitzgerald and Hallpike [21] and Barbey [22] it is not of much value, since it is strongly influenced by the bony structure of the petrous bone. On the other hand, Brunner [23] expressed the opinion that the time of latency is important and may indicate an alteration in the excitability of one labyrinth (Brünings [24]).

Clinically the most usual means of judging the results of the caloric test is the duration of the nystagmus. In this series I have tried to find the most reasonable way to perform the caloric test with the help of the nystagmus, especially its frequency time of latency and, most important, duration.

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17. Fischer, M. H.: Die Regulationsfunctionen des menschlichen Labyrinthes und die Zusammenhänge mit verwandten Funktionen, Ergebn. d. Physiol. **27**:209, 1928.

18. Woletz, F.: Studie zum vestibulären Erregungsablauf mittels des calorischen Nystagmus, Ztschr. f. Hals-, Nasen- u. Ohrenh. **30**:524, 1932.

19. Hennebert, P.: Inhibition periphérique des réactions vestibulaires, Bull. Soc. belge d'oto., rhinol., laryng., 1946, p. 86.

20. Grahe, K.: Zur Wirkungsweise des kalorischen Schwachreizes, Beitr. z. Anat., Physiol., Path. u. Therap. d. Ohres. **19**:101, 1923.

21. Fitzgerald, G., and Hallpike, C. S.: Observations on the Directional Preponderance of Caloric Nystagmus Resulting from Unilateral Labyrinthectomy, Brain **65**:115, 1942.

22. Barbey, E.: Les encephalopathies traumatiques au point de vue neurootologique, Arch. suisses de neurol. et psychiat. **50**:345, 1943.

23. Brunner, H., in Alexander G., and Marburg, O.: Handbuch der Neurologie des Ohres, Berlin, Urban & Schwarzenberg, 1924, vol. 1, p. 239.

24. Brünings: Ueber quantitative Funktionsprüfung des Vestibularapparates, Verhandl. d. deutsch. otol. Gesellsch., 1910, p. 180.

There is one point left to be considered. Is it useful to inhibit the fixation of the eyes with strong biconvex glasses as advocated by Bartels and Frenzel? As Hallpike [7] pointed out, those glasses do not make it easier to establish the end of the nystagmus. But, on the other hand, their use ascertains the exclusion of the purely nonvestibular factor introduced by fixation of the eyes.

Moreover, Frenzel's glasses enable one to see even the smallest movements of the eyeball by their magnification and good illumination. For these reasons I used the biconvex glasses of Frenzel in all experiments mentioned in the following section.

## EXPERIMENTAL SUBJECTS AND PRELIMINARY OBSERVATIONS

All the experiments were performed on normal subjects, students at the University Clinic, who never had any complaints concerning their ears, hearing or vestibular functions. The normal aspect of their ear drums was controlled before the performance of the tests.

Because of the difficulty of ascertaining the end of the nystagmus, a genuine pure issue of such experiments is not easily obtained; hence some precautions are desirable. To exclude any influence of the knowledge of other values already obtained in a subject, the stopwatch with which the duration of the nystagmus or of any other time is measured should be handled by a co-worker, who stops it at the indication of the observer. In order to measure the same thing every time, the observer has to know exactly what he wants to measure. In these experiments the nystagmus was considered to be present as long as the slow movement could be perceived clearly. The time of latency and the duration were measured from the end of the syringing.

The time of latency, always measured till the first quick movement, is in reality shorter, as a slow phase always precedes the quick one.

Nevertheless it is extremely difficult to see the real beginning of the nystagmus (slow phase). Since it takes much practice even for a person who has carried out the clinical caloric test for many years to be able to get results sufficiently reproducible that conclusions of general value may be drawn from them, the value of the time of latency can be based only on the beginning of the quick movement of the nystagmus, for it is considered impossible to measure it for the slow phase with enough certainty. The origin of the first quick movement, however, is influenced by so many extravestibular phenomena that its value as an indicator of vestibular activity should be strongly doubted.

For the practical use of the caloric test it is of the utmost importance to know how much time has to be allowed to pass before one applies another douche of the ear without danger of the results being influenced by the preceding test. Many investigators allow a long time to pass before they begin another syringing (about thirty minutes). To accomplish a thorough caloric test, with both ears syringed with cold and hot water, a very long time is needed (Brunner; [28] Hallpike; [7] Woletz [18]). On the other hand, the investigators who use the method of Kobrak with small quantities of water of a temperature not differing much from that of the body perform their tests, for

the most part, with only a small interval (van Deinse.[26]) According to Lorente de Nó,[27] the caloric nystagmus has the same duration as the stimulus, which means that the effect of the syringing is past as soon as the thermic effect in the skull is past.

While using water of a temperature not differing more than 10 degrees from that of the body we found that an interval between two tests of five to six minutes is long enough to get pure results. The duration of the nystagmus after syringing every six minutes is as constant as when we wait a longer time. A variation of 10 per cent is found in both instances.

The frequency varies so much that it cannot possibly be taken as a quantitative indication of the activity of the vestibular organ. Because the variation of the duration of the nystagmus following caloric stimulation varies normally 5 to 10 per cent, I have omitted any appearance of greater accuracy by approximating every value found in these tests to — 5 or — 0 seconds.

Figure 1 shows the result of one series out of many similar ones. The duration of the nystagmus after syringing with 50 cc. of water of a temperature of 30 C. with an interval of six minutes between douches is given; then the duration with an interval of twenty-four hours. The same is done for another

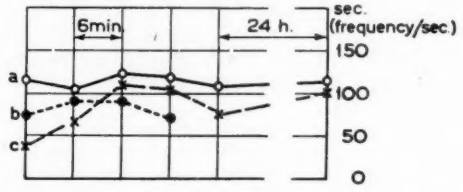


Fig. 1.—Line *a* represents the duration of nystagmus after an ear has been irrigated with 50 cc. of water of a temperature of 30 C. at intervals of six minutes. Line *b* gives the duration for another ear syringed with 5 cc. of water of a temperature of 30 C. every six minutes. Note the larger variation. The frequency of the nystagmus is shown by line *c*. Noth the absence of any regularity.

ear syringed with 5 cc. The frequency after each test in the first case is also demonstrated. This figure indicates some observations which I made repeatedly: An interval of six minutes—i. e., the time one needs to refill the syringe with water well adjusted to the right temperature after having read the reaction of the previous test and so to prepare the new one—is absolutely sufficient if one does not give too big a stimulus (see later comment). The results of a test performed with very small quantities of water are less constant than those of a test with larger quantities (50 cc. or more). The frequency of the nystagmus is by no means constant, not with small and not with longer intervals. If one allows some days to pass between two irrigations of the ears, one finds the same variations as with a pause of some minutes.

25. Footnote has been deleted.

26. van Deinse, J. B.: Het Ménière syndroom, Thesis, Amsterdam, 1946.

27. Lorente de Nó, R.: Einiges zur Labyrinthphysiologie, Acta-oto-laryng **11**:301, 1927.

### EXPERIMENTS ON THE POSITION CHAIR

With the data given in the foregoing section we tried to find the best position for testing the caloric excitability, using the position chair of Quix.[28] According to Brünings,[24] the stimulus—i. e., the temperature and the quantity of water necessary to cause nystagmus—is different with different positions. In my experiments I could neither corroborate this statement nor find any great influence of the position of the body over a large range.

With the subject lying straight on a stretcher, which may be placed in any possible position, it was found that only when the body was placed in such a manner that the horizontal canal was almost vertical did large variations occur. If the caloric test is performed with a certain quantity of water of a certain temperature, the duration of the nystagmus is almost the same except for the normal range of variation of 10 per cent, regardless of the turning of the body from an almost vertical position (head above) to about 150 degrees backward.

The same is observed if one passes the indifferent zone. With the subject turned forward from about 60 to about 180 degrees, the duration of the nystagmus following a definite stimulus is the same. We got the impression that the strength of the nystagmus was greatest in the horizontal position and decreased with the angle made by the body with the horizontal plane. It may be emphasized that the measurement of the nystagmus in the position in which the head (the body) is inclined forward is much more difficult than in the normal position, not only because the observer is obliged either to use a mirror or to take an inconvenient position to have a good look at the eyes and their movements in the subject, but also because the subject with his head bent forward is uneasy, especially if he is almost in the head down position.

This uneasiness has a great influence on the voluntary movements of the eyes. This is the reason why we did not trust the numbers in positions of the subject in which the head was down. To keep a person in that position long enough to measure the duration of the nystagmus accurately is so extremely disagreeable that I found myself able to accomplish this test with only a few subjects.

Figure 2 shows the results of a number of caloric tests made with 50 cc. of water of a temperature of 30 C. while the subject was on the position chair. The values given indicate the duration and the frequency of the nystagmus at such a position that the head points to the value in question, the body being turned on a binaural axis through the center.

In the same experiments we were able to corroborate entirely the issue of the investigations of Behrman.[29] The results of these experi-

28. Quix, F. H.: Nieuwe foestellen voor het klinisch ondersoek der functie van het vestibulaire organ, Nederl. tijdschr. v. geneesk. **71**:194, 1927.

29. Behrman, W.: Ueber Indifferenzlagen und Nystagmusgebiete: Versuche mit Kreisbewegung des Kopfes in der Sagittalebene nach einseitiger kalorischer Reizung, Acta-oto-laryng., 1940, supp. 40, p. 1; Versuche mit horizontal liegenden, nach einseitiger kalorischer Reizung um ihre Längsachse rotierten Personen, ibid. **30**:298, 1942.

ments duplicate those found earlier by de Kleyn and Storm van Leeuwen,[30] but they did not stress the fact that the angle of the upper region of the nystagmus is larger than that of the lower one.

The first is of the order of 200 degrees; the second, of the order of 140 degrees. The remaining angle is occupied by the zones of indifference.

We found almost exactly the same values in our experiments in contradiction to Veits,[31] who claimed that the zones of indifference diverge exactly 180 degrees.

Always, or nearly always, the nystagmus is of shorter duration in the reversed than in the normal position.

Still one other symptom is of importance for the performance of the caloric test—i. e., the influence of movements of the subject during the test. When a subject is tested in the reversed position and the duration is taken, we put him back in the normal horizontal position (lying on the back). In every instance we found that the nystagmus

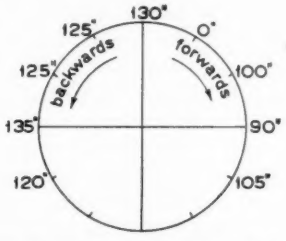


Fig. 2.—The duration of the caloric nystagmus of a subject on the position chair, measured in different positions on a binaural axis. The numbers indicate the duration in seconds. Each number belongs to the angle (next to which it is placed) indicating the inclination of the body.

belonging to the stimulus in that position occurred, but was of much longer duration. Some instances may illustrate this:

1. A caloric test with 50 cc. of water of 30 C. in the right ear causes nystagmus to the left of a duration of 180 seconds in a position 60 degrees backward and nystagmus to the right of 120 seconds if the body is in the reversed position, i. e., 120 degrees forward. If after the end of the last nystagmus the subject is turned back very slowly from the reversed position to the original backward position in such a way that only one or two vertical nystagmus beats are elicited, immediately nystagmus to the left starts again and lasts for 270 seconds. This nystagmus is almost purely horizontal with only a small rotatory component, not larger than a test performed entirely in the normal position would have

30. de Kleyn, A., and Storm von Leeuwen, W.; Ueber vestibuläre Augenreflexe: III, Arch. f. Ophth. **107**:109, 1921.

31. Veits, C.: Zur anatomischen Charakteristik der absoluten kalorischen Indifferenzlage, Arch. f. Ohren-, Nasen- u. Kehlkopfh. **118**:303, 1928.

shown. 2. The same test in another subject performed with water of 44 C. gave a duration of the nystagmus to the right of 90 seconds in the normal 60 degree backward position and a duration of nystagmus to the left of 90 seconds, likewise, in the reversed 120 degrees forward position. After the subject was brought back to the normal position the nystagmus to the right returned and continued for more than 180 seconds, i. e., a total duration of about 300 seconds.

However, in repeating such an experiment, even when we tried to make every part of it identical as compared with the previous one, we found other values not for the primary reaction but for the duration of the nystagmus after the movement. It may be superfluous to state that we never found horizontal nystagmus after turning the subject on a binaural axis if no thermic stimulus was applied.

This result causes us to doubt the quantitative value of any caloric test performed on a patient who is moved during the test as indicated, for instance, by Brünings [4] and Fischer.[6] The rotatory component of the nystagmus may be of great importance neurologically, as claimed by Aubry,[32] but in that case the measurement of this rotatory component in the Brünings position optimal to obtain it cannot be combined with a quantitative determination of the duration of the nystagmus in the normal position.

Concluding, one may state that for the caloric test the best position of the patient is that of lying horizontally with the head raised on a pillow at an angle of about 30 degrees. In this way the patient is as much at ease as possible and the nystagmus is strongest. There is no need to obey stricter rules, since over a large range the duration of the nystagmus is identical, and it is fairly easy to keep the patient in the same position during the whole time of a caloric examination made on both ears with hot and cold water.

### INFLUENCE OF THE QUANTITY OF WATER USED IN THE CALORIC TEST

With the subject in the aforementioned position, I have tried to ascertain the quantity of water most suitable for the caloric test. A priori one would be inclined to think that the quantity of water should be of great importance to the duration of the nystagmus. Nothing appears to be less true. If water is used at a temperature not too near body temperature—for instance, 30 and 44 C.—the influence is absolutely negligible. Figure 3 gives some examples of the duration of the nystagmus in caloric tests with different quantities of water. If the temperature differs much from that of the body, the duration of the nystagmus after small quantities of water is usually longer than after large quantities (upper line). This is what Kobrak called the

32. Aubry, M.: Oto-neurologie: Technique et interprétation des examens labyrinthiques, Paris, Masson & Cie, 1944.

inhibition of the nystagmus by large quantities of water. We do not share his opinion on the main points of the problem, but we hope to discuss this in a later paper.

The two middle lines of figure 3 indicate the duration of the nystagmus with different quantities of water at the temperatures 30 and 44 C.

It is obvious that the influence of the quantity is of no importance here for the duration. On the other hand, the lower curve is obtained with water of 35 C. Here a large quantity induces a longer nystagmus than a small quantity.

These results, however, do not imply that the quantity of water is of no importance at all. It is difficult to measure the end of the nystagmus if one uses small quantities of water. A subject whose ears are syringed with, let us say, 5 cc. of water has many irregularities in the movements of his eyes, especially at the end of the nystagmus. He has voluntary movements of the eyes, or apparently such, which he is unable to dominate; he blinks his eyelids; sometimes even the

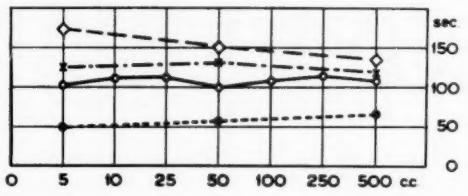


Fig. 3.—The duration of the nystagmus is set out as a function of the quantity of the water used for the test (abscissa). The upper line indicates the values found for water of a temperature of 18 C. The second line is for water of 30 C., the third, for water of 44 C., and the lowest line, for water of 35 C. The graphs are taken from four different subjects; each series, from one subject.

pupils quickly alter in size, and, finally, the magnitude of the nystagmus is usually very small. These factors make it extremely difficult to get reliable results.

If larger quantities are used, these difficulties do not arise to such an extent. On the other hand, it is impracticable to use large quantities of water, which give good results but require special instruments and arrangements for the tests and are more liable to cause vertigo and sickness in the patients.

A moderate quantity of about 50 cc. has many advantages. It does not require special arrangements; a normal ear syringe, according to Alexander, has a capacity of about 50 cc. It is enough to avoid the trouble of the very small quantities and not so much as to cause great trouble to the patient.

Concluding, I advocate that about 50 cc. of water be used in the performance of the caloric test, on account of its practical advantages.

### INFLUENCE OF THE TEMPERATURE OF THE WATER USED IN THE CALORIC TEST

The influence of the temperature of the water is much greater than that of the quantity but not as great as one might be inclined to think. As long as the temperature differs little from that of the body an increase of this difference causes an important increase of the duration of the nystagmus, but as soon as the difference is of the order of about

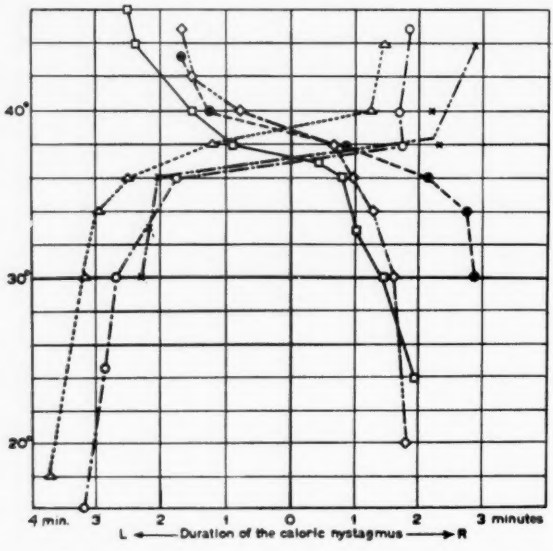


Fig. 4.—The duration of nystagmus following syringing of the ear with water of different temperatures is put down as a function of the temperature of the water used for the test. On the right side nystagmus to the right is recorded and on the left side nystagmus to the left. The subjects were in the horizontal position. The quantity of water used was 50 cc.

5 degrees a further increase is accompanied by only a small increase in the duration of the nystagmus, so that the difference between the reactions is often less after syringing with water of 30 and of 18 C. than that after syringing with water of 35 and 32 C. The diagram in figure 4 shows these facts.

In most instances the reversion of the nystagmus does not occur at the temperature of the body but at 1 or 2 degrees above it. This is not due to the fact that the temperature of the water decreases during

the test, so that the temperature is lower than the measured one. This was proved by experiments during the caloric test in which the temperature at the ear drum was taken with the help of a thermoelectric point. It also indicated that the direction of the induced nystagmus changes at a temperature which lies mostly above that of the body and may even be as high as 39 or 40 C. This does not quite agree with the classic theory of Bárány about the origin of the caloric reaction, but this paper is not the proper place to discuss the problem. The graph in figure 4 takes an asymptomatic course as soon as the difference of the temperature of the water and that of the body is large enough. At 34 and 42 C. the beginning of this asymptomatic course is obvious usually and at 30 and 44 C. always. That a difference of less than 1 degree may cause a clear reaction is shown also in figure 4 (Plum [33]). Using these temperatures, one is practically sure to examine the patients in the vertical part of the graph. Stimuli of greater intensity (greater difference of temperature) only cause greater trouble in the subject (pain, sickness, vertigo); they do not give a better result. In our clinic we therefore use water of a temperature of 30 and 44 C., these being stimuli equidistant from body temperature which give good nystagmus without eliciting troublesome symptoms (Hallpike [7]).

Concluding, I advise that water of 30 to 44 C. be used for the caloric test, as these temperatures yield the best results with the least trouble.

### INFLUENCE OF ADVENTITIOUS MEASURES ON THE CALORIC TEST

Especially in the tests according to Kobrak, with very small quantities of water, it always is advisable to point the jet of water against the upper rear part of the ear drum to get the best results.

I could not find any difference in the duration or in the strength of the nystagmus whether the jet was pointed at different parts of the drum or at the wall of the external auditory canal so long as the water streamed amply along the drum. If the direction of the jet was changed during the test, no difference of the temperature of the drum was observed. This was also the case when small quantities of water were used; within large limits the same temperature, as well as the same reaction, was measured at the drum. Carried into practice this means that one needs only to be careful to direct the syringing water amply through the auditory canal.

As little influence as the quantity of water has on the caloric reaction, just so little is the influence of the rapidity of the irrigation of the ear if only the beginning of the reaction is measured from the same point,

33. Plum, A.: Methode zur quantitative Messung, Beitr. z. Anat. Physiol. u. Therap. d. Ohres. **18**:342, 1920.

i. e., the end of the syringing. We use a moderate velocity of about three seconds per 5 cc., i. e., thirty seconds for a normal test of 50 cc.

It stands to reason that before performing the caloric tests one ascertains that no piece of cerumen closes the auditory canal. However, the influence of a little piece of cotton or even cerumen is not as great as one would be inclined to think, at least when larger quantities of water are used. An example may illustrate this:

A left ear with an obstructing piece of cerumen gave the following reactions when syringed with 50 cc. of water at 30 C.

| | |
|---|---|
| Duration | 210 seconds |
| Time of latency | 30 seconds |
| Frequency | 130 beats |

After the removal of the cerumen the values were:

| | |
|---|---|
| Duration | 210 seconds |
| Time of latency | 15 seconds |
| Frequency | 160 beats |

Concluding, one sees that the influence of the speed and the direction of the stream of water is extremely small. Also the influence of small pieces of cerumen is negligible.

### BILATERAL TESTS

In order to support the data recorded to this point, we tried to verify them with bilateral tests.

The bilateral syringing of both ears at the same time with the same stimulus was indicated by Bárány and later used by Fischer,[34] Ruttin,[35] Quix,[36] de Kleijn and Versteegh [37] and others.

If the stimulus is exactly the same on both sides, there is, for the most part, no nystagmus of the second degree behind Frenzel's glasses. However, if one property of the stimulus is changed, a large difference may be introduced without any effect. Not before the quantity of the water applied in one ear is five times as much as the quantity in the other ear does nystagmus of the second degree originate; 10 cc. at one side and 50 cc. at the other side may be tolerated without any effect if one takes care to end the stimulation at the same moment. If one uses

34. Fischer, M. H.: Beiträge zur Physiologie des menschlichen Vestibularapparates: V. Bilateralmethoden, speziell Doppelspülungen, Arch. f. d. ges. Physiol. **213**:74, 1926; footnote 12.

35. Ruttin, E.: Zur Differenzial-diagnose der Erkrankungen des vestibularen Endapparates, der Vestibularnerven und seiner zentralen Bahnen, Verhandl. deutsch. otol. Gesellsch., 1909, p. 169.

36. Quix, F. H.: Verschijnselen bij het uitspuiten van beide oren tegelijk, Nederl. Tijdschr. geneesk. **74**: 1975, 1930.

37. Versteegh, C., and de Kleijn, A.: Some Remarks upon Present Position of Physiology of Labyrinth, J. Laryng. & Otol. **42**:649, 1927.

the same quantity of water on both sides, one may change the temperature at either side by many degrees without any effect.

If the temperatures in the vertical part of graph 4 are taken, a difference of temperature of 5 degrees is usually tolerated without any nystagmus, while a difference of 10 degrees generally causes definite nystagmus. Syringing in different directions at the two sides has no influence.

## CONCLUSIONS

The best method of performing the caloric test is discussed, and reasons are given why the duration of the nystagmus is the best indicator of the reaction of the labyrinth on caloric stimulation. The time of latency, the frequency and the sensations of the subject are less suitable on account of their unreliability. The influence of the position is examined; the best position for the test is the normal horizontal position with the head lifted up some 30 degrees on a pillow (Brünings). The influence of the quantity of water is extremely small. For purely practical reasons, the use of 50 cc. is recommended. This quantity

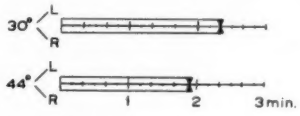


Fig. 5.—Diagram after Hallpike [7] to register the results of the caloric test. On the diagram the duration and, if necessary, the time of latency may be indicated for both ears at temperatures of 30 and 44 C. Directional preponderance or domination of the reaction of one labyrinth may be read immediately from this diagram. The points given here are the average values of 60 normal subjects.

gives a reaction which is easily measured and does not need special arrangements. A normal ear syringe has this capacity.

The best temperatures to use are about 30 and 44 C., as with these the maximum reactions are obtained with the smallest stimulation, and they do not cause disagreeable symptoms in the patients. There is no need to be especially careful with the direction and the speed of the syringing, as the influence of these factors is small or nonexistent.

Experiments with bilateral syringing confirmed the data mentioned. The diagram given by Hallpike (fig. 5) has proved to be extremely useful in the clinical registration of the caloric test.

As set forth in the foregoing pages, the use of cold and warm water is necessary not only to be sure of the presence of any remainder of function of a labyrinth but also to distinguish between directional preponderance and predomination of one labyrinth, a distinction seemingly of great importance for neurologic symptomatology (Hallpike [7]).

SUMMARY

On account of experiments made in performing the caloric test on normal subjects, the preferable method of performing this test seems to be the following: The subject is placed in the normal horizontal position, the head flexed on a pillow at 30 degrees. Both ears are syringed with 50 cc. of water at temperatures of 30 and 44 C.

The interval between the four tests necessary to make a complete caloric examination of vestibular function need not be longer than six minutes. In this way the duration of the whole examination is not longer than about twenty minutes, and it gives every result which may be expected from this kind of examination. The use of the diagram of Hallpike is recommended.

# BENIGN CYSTS OF THE PARANASAL SINUSES

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BENIGN cysts which are common in and peculiar to the paranasal sinuses are of two general types, those which take origin from the sinus mucosa and those which invade the maxillary sinuses from the teeth. Dermoids and cysts of the facial cleft, which frequently involve the nasal structures, rarely involve the paranasal sinuses proper. While the pathogenesis of some types of cysts found in the sinuses is fairly well understood, the development of others is not adequately explained, nor is the etiology of certain types established.

A simple classification of these cysts is as follows:

A. Cysts arising from the sinus mucosa
   1. Nonsecreting cysts
   2. Secreting cysts
      (*a*) Retention (glandular) cyst
      (*b*) Mucocele

B. Odontogenic cysts
   1. Follicular cysts (dentigerous [1])
   2. Radicular (root) cyst

This classification does not include cystic neoplasms; therefore adamantinomas, which may become cystic, are not included.

## CYSTS ARISING FROM THE SINUS MUCOSA

### NONSECRETING CYSTS

The nonsecreting cyst is an accumulation of straw-colored exudate in the subepithelial, loose connective tissue of the maxillary sinuses. Clinical and roentgenologic evidence of its occurrence in other sinuses is lacking.

*Pathologic Factors.*—The pathogenesis of this cyst is not clear. Areas of the subepithelial stroma adjacent to such cysts frequently show accumulations of fluid in the tissue spaces. MacGregor [2] pointed out that an increasing accumulation of fluid in the tissue, with the breakdown of interstitial connective tissue septums and the coalescence of these small

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1. A dentigerous cyst is a follicular cyst which contains a tooth.

2. MacGregor, G. W.: The Formation and Histological Structure of Cysts of the Maxillary Sinus, Arch. Otolaryng. **8**:505-519 (Nov.) 1928.

cystic areas, would explain the formation of a larger cyst. These changes in the subepithelium are probably inflammatory. Multiple microscopic collections of fluid are commonly seen with hyperplasia of the sinus mucosa, whether on an allergic or an infectious basis. The typical pathologic picture is shown in figure 1 *A*. Clinically, these cysts are associated more frequently with infection than with allergy.

The selective occurrence of these cysts in the maxillary sinus is best explained on an anatomic basis. The interstitial fluid probably collects on the floor of the antrum by the force of gravitation, and the thin walls are prevented from rupture by the support of the bony walls of the sinus.

The wall of the cyst varies in thickness but is generally very thin. The lining membrane consists of a few strands of fibrous tissue, and the wall is infiltrated with varying numbers of eosinophils, lymphocytes, plasma cells and neutrophils, the distribution depending on the inflammatory response incited. The sinus mucosa is reflected over the top of the cyst. Eichelberger and Lindsay [3] made a chemical analysis of the fluid of the cyst in 11 cases and found the protein values, specific gravity and pattern of electrolytes to be approximately those of an inflammatory exudate.

*Symptoms.*—Symptoms usually are not evident in the case of very small cysts but become evident as the cyst enlarges. A cyst which appears to occupy the lower half or more of the sinus is capable of producing not only local symptoms but also generalized complaints of fatigue, lassitude, headache, dizziness and irritability. This cyst is a relatively common occurrence in clinical practice and was found by Grossman and Waltz [4] in 6 cases in 80 consecutive roentgenograms of the sinuses. In 3 of these cases the patients complained of toothache and were relieved by puncture of the antrum. Straus [5] reported a case in which optic neuritis began to subside two days after removal of a nonsecreting cyst. Lindsay [5a] noted that removal of nonsecreting cysts in 3 cases of infectious arthritis resulted in relief of symptoms in 2 cases and precipitation of a severe attack in the third case. Although ordinary methods almost always show the fluid from the nonsecreting cyst to be sterile, there is clinical evidence that it may act as a toxic focus.

3. Eichelberger, L., and Lindsay, J. R.: Chemical Composition of Fluids from Benign Cysts of the Antrum, Proc. Soc. Exper. Biol. & Med. **48**:191-195 (Oct.) 1941.

4. Grossman, J. W., and Waltz, H. F.: Non-Secreting Cysts of the Maxillary Sinus, with Special Reference to the Roentgen Aspects and Diagnosis of the Large Types, Am. J. Roentgenol. **52**:136-144 (Aug.) 1944.

5. Straus, G. D.: Mucosal Cysts of the Maxillary Sinus, Laryngoscope **54**: 267-276 (June) 1944.

5a. Lindsay, J. R.: Nonsecreting Cysts of the Maxillary Sinus Mucosa, Laryngoscope **52**:84-100 (Feb.) 1942.

*Clinical Course.*—A cyst once formed may persist and increase in size until spontaneous rupture occurs. A very small cyst may disappear without the sudden unilateral discharge of fluid that would indicate rupture. On the roentgenogram the nonsecreting cyst appears as a dome-shaped shadow arising from the floor of the antrum. It may,

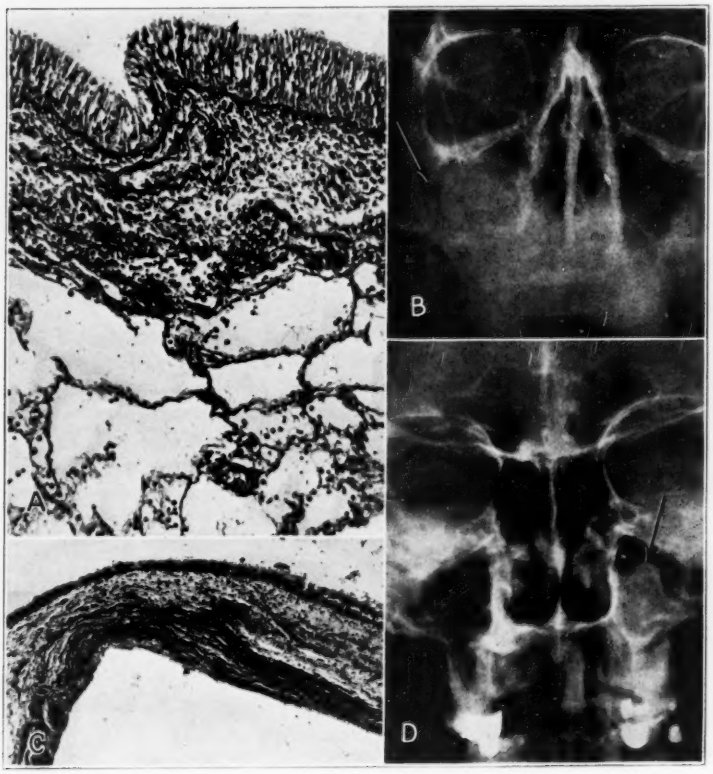


Fig. 1.—*A*, hyperplastic sinus mucosa. The fluid spaces seen in the subepithelial connective tissue layer may by confluence lead to the formation of a cyst. *B*, cystic polyp of the left maxillary sinus. An important diagnostic point in this film is that the lateral wall of the polyp stands away from the bony sinus wall (arrow); however, this situation is not present in all cases. *C*, the wall of a nonsecreting cyst (case 1), stained with Mallory's connective tissue stain. The cystic cavity is lined by a layer of fibrous connective tissue. *D*, nonsecreting cyst in right antrum (arrow) (case 1).

however, fill the sinus and produce complete homogeneous clouding, which cannot be differentiated roentgenologically from empyema. There

is no alteration in the bony wall of the sinus, and a sinus containing such a cyst with minimal other pathologic changes generally may be transilluminated well. Millhon and Brown [6] recently reported finding dome-shaped cysts in the maxillary sinuses in 24 of 600 consecutive complete dental roentgenograms. They noted that 1 cyst had been present without change in size for six years, and yet that others had disappeared in a year. Wright [7] reported that round shadows in the maxillary sinuses were present in about 5 per cent of all roentgenograms of sinuses taken in a military hospital.

Large degenerating polyps may become cystic and give a roentgenologic appearance similar to that of the nonsecreting cyst. Differentation is possible, however, in some cases, such as that illustrated in figure 1 *B*, in which the lateral wall of the polyp stands away from the bony wall of the sinus. Histologically, this growth proved to be a thick-walled, degenerating polyp with large central cystic spaces containing straw-colored fluid. A nonsecreting cyst presents a roentgenologic shadow of uniform density, whereas cystic polyps, because of their irregular shape, will sometimes create shadows of irregular density.

A fluid level is easily differentiated from a nonsecreting cyst by its flat horizontal surface and by the meniscus which can usually be seen. Also, the surface of a fluid level remains horizontal in all positions of the head, whereas the shadow of a nonsecreting cyst will not change its shape or position.

Dental cysts involving the antrum may create a roentgenologic shadow which may be confused with that of the nonsecreting cyst. A follicular (dentigerous) cyst which contains a tooth may be easily distinguished; however, when a tooth is not present, roentgenologic differentiation may be more difficult. Both follicular and radicular cysts destroy bone as they expand and may completely erode through one or more of the bony sinus walls, with resulting facial or intranasal deformity. Nonsecreting cysts, on the other hand, never affect the bony sinus wall. A radicular (root) cyst bulging up into the antrum may also have a more irregular upper border than has the nonsecreting cyst.

*Treatment.*—Occasionally a nonsecreting cyst may disappear after spontaneous rupture or after puncture and lavage of the antrum. In many cases the removal of part or all of the cyst wall through an antrum window operation may result in a cure. Complete removal is sometimes necessary for a clinical cure. In cases in which there is also an

6. Millhon, J. A., and Brown, H. A.: Cysts Arising from Mucosa of Maxillary Sinus as Seen in Dental Roentgenogram, Am. J. Orthodontics (Oral Surg. Sect.) **30**:12-15 (Jan.) 1944.

7. Wright, R. W.: Round Shadows in the Maxillary Sinuses, Laryngoscope **56**:455-489 (Aug.) 1946.

extensive hyperplastic change in the sinus mucosa it is necessary to perform a radical removal of the contents of the sinus, for which procedure the Caldwell-Luc operation is preferred.

CASE 1.—S. S., a woman aged 57, had severe osteoarthritis of the spine. In a search for foci of infection, roentgenograms of the sinuses were made and revealed a dome-shaped shadow arising from the floor of the right antrum (fig. 1 *D*). The patient had no local symptoms to indicate disease of that sinus. A curved punch was introduced into the cyst through the inferior meatus, and 6 cc. of straw-colored fluid was removed. Staphylococcus aureus and Staphylococcus albus were cultured from this fluid. Three weeks later radical maxillary sinusotomy (Caldwell-Luc operation) was performed on the right side. The mucosa of the sinus was found to be decidedly hyperplastic and to contain numerous small retention cysts. There was a thick folded membrane, representing the collapsed cyst wall, in the floor of the sinus (fig. 1 *C*). Recovery from the operation was uneventful. The patient was not kept under observation long enough for one to determine the extent of improvement of the arthritis. The case presented one of the rare instances in which organisms were cultured from the cyst fluid. It is possible that the cyst fluid or the culture mediums were contaminated.

The diagnosis was a nonsecreting cyst of the right maxillary sinus.

### RETENTION CYST

Blockage of the duct of a tuboacinose gland of the sinus mucosa results in a cystic dilatation of the gland by accumulating secretions. Such a cyst never becomes large. At operation the cyst is often described erroneously as a small abscess. It appears as part of the histopathologic picture in chronic inflammation or hyperplasia of the sinus mucosa, of either allergic or infectious cause.

*Pathologic Factors.*—A number of these cysts were sectioned serially and the glandular duct examined histologically. There was usually pronounced hyperplasia of the normally columnar ciliated epithelium of the duct, which had become thick and pseudostratified, with resulting appreciable narrowing of the lumen of the duct. This situation is well shown in figure 2 *A*. The effect of toxins on ciliary action must be considered also as a cause of retention.

The wall of the cyst is lined with a single layer of cuboidal cells. Beneath this secretory epithelium is a loose connective tissue stroma, containing acute or chronic inflammatory cells in varying numbers (fig. 2 *B*).

*Clinical Significance.*—This cyst is apparently not symptomatic in itself, and it is not evident individually, either clinically or roentgenologically.

### MUCOCELE

A mucocele is an accumulation of the products of secretion, desquamation and inflammation within a paranasal sinus, with distention of the walls of the sinus. True mucoceles occur typically in the frontal

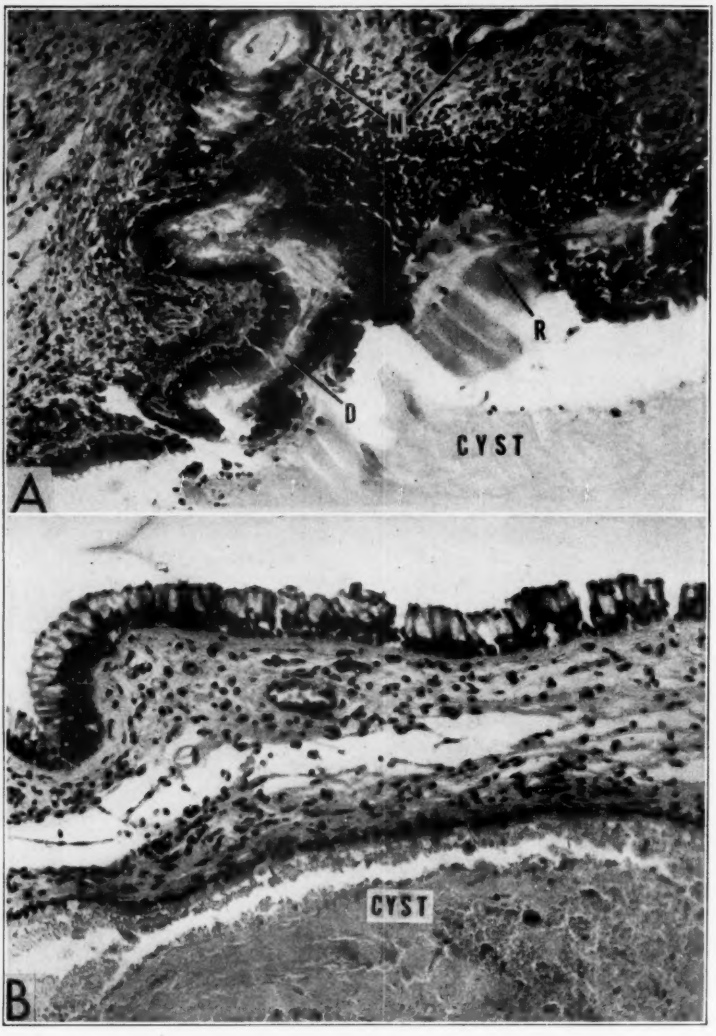


Fig. 2.—*A*, duct of a retention (glandular) cyst. *D* indicates a narrow, tortuous gland duct with hyperplastic epithelium; *N*, cuboidal epithelium of more normal-appearing ducts, and *R*, rupture of cyst wall with round cell infiltration. *B*, the wall of a retention cyst. The mucosa of the maxillary sinus is reflected over the top of the cyst.

sinus and ethmoid cells, and more rarely in the maxillary or sphenoidal sinuses. Many cases described in the literature as those of mucocele of the maxillary sinus have been instances either of a nonsecreting cyst or of a dental cyst. In our experience, over half the operations for chronic inflammatory disease of the frontal sinus were performed for the treatment of mucocele.

*Pathologic Factors.*—Obstruction of the nasofrontal duct or a particular ethmoidal ostium probably occurs in all cases of true mucocele. Our experience indicates that blockage of the nasofrontal duct may occur temporarily in an acute episode without formation of a mucocele. However, the recurrence of acute attacks associated in some instances with blockage apparently increases the probability of an eventual permanent blockage and formation of a mucocele. In a comprehensive review of the literature, Wilkerson [8] noted that trauma, neoplasm and regional infections have been commonly considered etiologic factors in the narrowing and obstruction of these small passages. The dependent position of the ostium of the frontal sinus may be a predisposing factor in that during an acute attack with obstruction the products of inflammation accumulate at that point and predispose the opening to increasing fibrosis and stenosis. Whether or not the mucocele always takes origin during an acute inflammatory episode is not definite. A slow, progressive blockage of the ostium and gradual replacement of air by the accumulating secretion and cellular debris might occur and explain the absence of the pain which usually occurs in cases of acute obstruction. Lobell [9] noted that apparent obstruction of the nasofrontal duct can occur without formation of the classic mucocele. He expressed the belief that some form of cystic degeneration of the sinus mucosa must take place before a mucocele develops.

Histologic examination of the wall of a mucocele reveals that it is the distended mucoperiosteal lining of the sinus throughout. This is demonstrated in figure 3 *B*, *C* and *D*. The pseudostratified columnar epithelium normally seen on the surface is compressed into low columnar or cuboidal epithelium, with occasional goblet cells. There is a pronounced decrease in tuboacinose glands. The epithelium rests on a dense connective tissue wall of varying thickness, the stroma usually showing mild infiltration with small round cells.

*Symptoms.*—There is usually a history of previous attacks of frontal or ethmoidal sinusitis. In some of these episodes there may have been swelling of the upper lid, or an orbital abscess may have been drained.

8. Wilkerson, W. W., Jr.: Mucocele of the Nasal Accessory Sinuses, Laryngoscope **55**:294-308 (June) 1945.

9. Lobell, A.: Relationship Between Mucoceles and Cysts: Report of Cyst of Maxillary Sinus, Arch. Otolaryng. **6**:546-551 (Dec.) 1927.

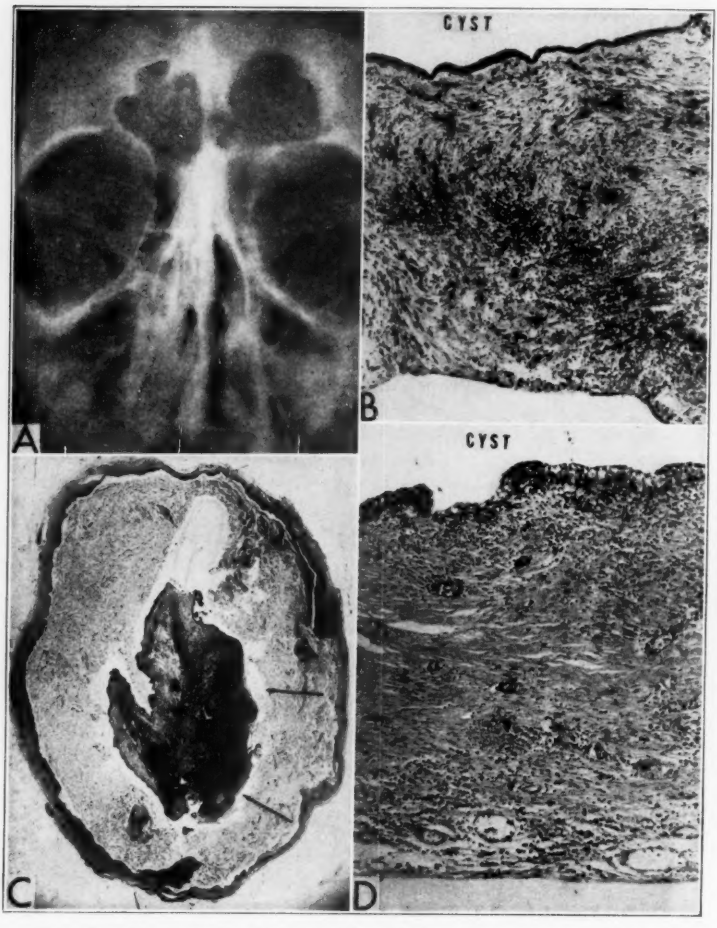


Fig. 3.—*A*, a mucocele of the right frontal sinus. The bony walls have lost their septate appearance. There is a mild, bordering osteosclerosis. *B*, wall of the mucocele shown in *A*. The epithelium of the sinus mucosa is conspicuously compressed. The subepithelial tissue consists of a thick layer of dense fibrous tissue infiltrated with lymphocytes. *C*, photomicrograph of another mucocele of the frontal sinus which was removed intact. The mucoperiosteum of the sinus forms the wall of the cyst throughout. Part of the thickened wall has been displaced into the cyst. *D*, higher magnification of the wall of the mucocele shown in *C*.

The development of the mucocele, however, is usually slowly progressive and the onset not clearly related to an acute attack. Generally the patient first notices a downward and outward displacement of the eye. Because the displacement is slow, diplopia developes only late, if at all. Visual impairment, limitation of movement of the globe and ptosis may occur. Nasal blockage on the involved side may result from expansion of the mucocele into the nasal passage.

*Clinical Findings.*—As the mucocele increases in size, there is pressure erosion of the bony walls of the sinus, which often become so thin as to crepitate on palpation. This painless expansion may progress to involve the orbit, nasal cavity, anterior cranial fossa and anterior wall of the frontal sinus, with deformity of the forehead. Characteristically, there is palpable a tense elastic mass beneath the medial aspect of the supraorbital ridge. The eye is usually displaced forward, downward and laterally. Intranasal deformity is more commonly associated with ethmoidal mucoceles. Infection of the contents of the cyst may lead to a pyocele, with signs of acute inflammation (fig. 4). Erosion of the posterior wall of the frontal sinus predisposes to the occurrence of an intracranial complication during an acute exacerbation.

Roentgenologic findings depend entirely on the size and location of the mucocele and the amount of deformity caused by it. The contents of the cyst render the cavity slightly less radiolucent than the normal, air-filled sinus; however, pressure erosion of the bony walls due to the expansion of the cyst may more than offset this added density.[10] In the early stages there may be mild osteosclerosis of the sinus wall, as a result of reactionary bone formation, but as the cyst increases in size the borders of the sinus lose their septate appearance, and the margins of the expanding cavity become smooth and rarefied until but a thin shelf of bone remains (fig. 3 *A*).

*Treatment.*—Mucocele requires surgical treatment. Those situated in the ethmoidal sinus and those of the frontal sinus which have expanded downward so as to involve the anterior ethmoidal cells may be suitable for an intranasal operation. However, in our experience, the number which can be treated in this way is small. In most cases an external frontal sinusotomy has been required for sufficient exposure. An essential part of the surgical treatment of mucocele of the frontal sinus is the complete removal of the remaining parts of the floor of the frontal sinus and all frontoethmoidal cells. In most cases, the anterior ethmoidal cells have been at least partly involved, and the nasofrontal duct has been irreversibly damaged. It is necessary then to do an exenteration,

10. Hartung, A., and Wachowski, T.: Mucocele of the Frontal Sinus, with Special Reference to Roentgen Aspects and Report of Four Cases, Am. J. Roentgenol. **34**:30-36 (July) 1935.

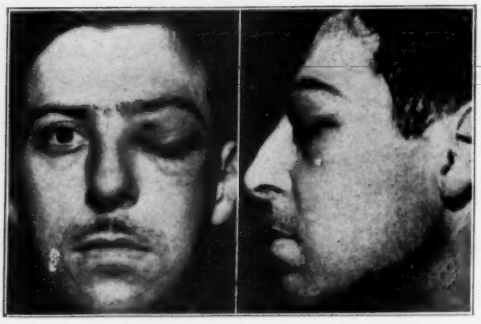

Fig. 4.—Infected mucocele of the left frontal sinus (pyocele) (case 4).

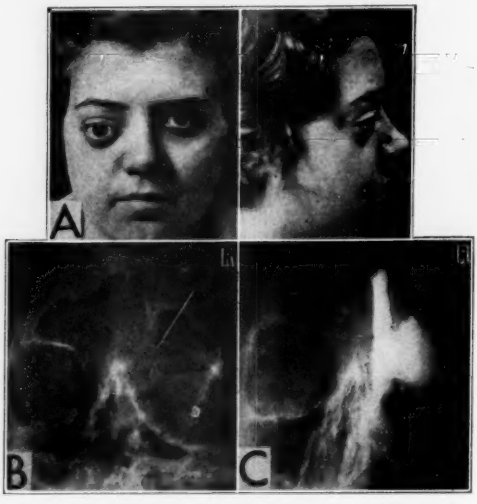


Fig. 5.—*A*, mucocele of the frontal sinus (case 2). Preoperative views show the typical proptosis and downward and lateral displacement of the right eye. *B*, a preoperative roentgenogram of mucocele of the frontal sinus (case 2). There is complete absence of the middle two thirds of the right supraorbital ridge. *C*, a roentgenogram in the same case two months after operation, showing the right frontal sinus completely filled with iodochlorol® (chloriodized peanut oil, representing 27 per cent of iodine and 7.5 per cent of chlorine). The outline is sharp and in direct contact with the bony walls.

being careful to remove all parts of the floor of the frontal extensions of the ethmoidal cells, as well as those of the floor of the frontal sinus. A large opening is then provided into the nose through the enlarged nasofrontal duct and anterior ethmoidal cells. Experience has shown that in some cases there is a tendency to postoperative closure of this nasofrontal opening. Poor drainage, with a tendency toward chronic suppuration, is the result. Because of the tendency to closure and recurrence of suppuration, it is essential that the surgical steps be carried out as carefully in the case of a mucocele as in that of chronic suppuration of the frontal sinus.

Case 2.—B. J., a girl aged 16, first came to the ear, nose and throat clinic with the history that her right eye had begun to protrude eleven months before and that the condition was becoming worse. There were now headaches in the right frontal area.

At the age of 6 the patient had had an infection of the upper respiratory tract, after which the right eye had become swollen and red. Incision of the upper lid had been followed by purulent drainage. This history suggested acute suppurative ethmoiditis and orbital cellulitis. However, the age of the patient did not preclude acute frontal sinusitis as well.

Examination revealed proptosis and lateral and downward displacement of the right eye (fig. 5 *A*). There was diplopia on left lateral gaze. Palpation revealed a defect in the medial two thirds of the supraorbital ridge. In this region and in the superior medial aspect of the orbit was a firm, elastic, nontender mass. Roentgenograms of the sinuses revealed complete absence of the medial two thirds of the supraorbital ridge (fig. 5 *B* and *C*).

An external frontal sinusotomy was done, revealing a cystic cavity filled with mucopurulent material. The cyst lay partially within the orbit and had obliterated part of the anterior ethmoidal cells and the nasofrontal duct. A wide opening was made from the nasal fossa directly into the cystic cavity, the cystic lining being left in place. Because this nasofrontal opening had a tendency to close, the patient used a nasofrontal duct dilator at home for several months Recovery was otherwise uneventful.

The diagnosis was a mucocele of the right frontal sinus.

Case 3.—B. H., a woman aged 33, was first seen by us on Feb. 8, 1940. She gave the history of having had right-sided headaches and swelling around the right eye at the age of 15. At the age of 16 she had had an intranasal operation but had experienced no relief from symptoms. The following year an external nasal operation had been performed on the right frontal sinus and had given relief from headaches. For the past five years she had noted gradual displacement and loss of vision in the right eye. One month prior to admission the right-sided headaches had recurred.

The patient presented the pronounced facial deformity seen in figure 6 *B*. The right nasal cavity was filled with a large bulging mass, pushing the nasal septum to the left. There was a complicated cataract of the right eye, and the patient could detect only hand movements at 3 feet (90 cm.). Roentgenologic examination (fig. 6 *A*) revealed a multilocular lesion of the right frontal sinus, which extended into the orbit, nasal cavity and maxillary sinus on that side and bulging into the anterior cranial fossa. The right frontal bone was thickened above the lesion (chronic proliferative osteomyelitis).

On February 14, an external radical frontoethmoidal sinusotomy was performed on the right side, revealing a huge cavity in the frontal and ethmoidal area, the cavity was filled with a large cyst containing a thick, mucoid secretion. The cyst extended into the orbit and the maxillary sinus. The remaining ethmoidal cells were removed. The dura was exposed widely. A wide opening was left from the nasal fossa into the cystic cavity. Cultures grew Staph. aureus and Staph. albus.

Recovery was uneventful.

The diagnosis was mucocele of the right frontal sinus, encroaching on the ethmoidal and maxillary sinuses and the anterior cranial fossa.

Fig. 6.—*A*, mucocele of the right frontal sinus (case 3). There is expansion of the cyst into the orbit, nasal cavity, maxillary sinus and anterior cranial fossa. The frontal bone is thick and sclerotic above the right frontal sinus (chronic proliferative osteomyelitis). *B*, photograph of the patient in case 3, showing the displacement of the right eye and deformity of the frontal area.

Case 4.—A. L., a man aged 26, when first seen on June 28, 1930, gave a history of having received a blow to the forehead two years previously, after which injury he had had a swelling and much pain over the left eye. Since that time, he had had headaches in the left frontal area. These had occurred about once a month and had lasted two or three days. One month prior to consultation the headache had been accompanied with swelling of the left upper eyelid. The only finding was pus in the left middle meatus. The roentgenogram showed complete clouding of the left frontal sinus and partial clouding of the left antrum. A purulent

secretion was obtained repeatedly on lavage of the antrum. A nasoantral window was made on the left side; after this operation the patient was free of symptoms until 1938 (eight years), when he began again to have occasional headaches in the left frontal area, accompanied occasionally with swelling of the left upper eyelid.

On July 23, 1942, there developed a tender, red, edematous swelling of the left frontal area and upper eyelid with constant, severe pain localized to that area and accompanied with fever and malaise (fig. 4). Roentgenologic examination revealed clouding and an irregular outline of the left frontal sinus, with decided sclerosis around the border. Vision was normal, and the fundi were clear. The general physical and neurologic examination revealed an essentially normal condition.

An external radical frontal sinusotomy was performed the following day. A large, pus-containing cavity was opened. There were granulations on the posterior wall. At this point the bony wall was dehiscent, and a large abscess cavity in the anterior cranial fossa was exposed. The extent of the abscess cavity could not be definitely determined. The anterior ethmoidal cells were completely exenterated, care being taken to remove any remnants of the floor of these cells and of the frontal sinus. Cultures grew hemolytic streptococci and Staph. aureus. There was drainage of cerebrospinal fluid from the sinus for about two weeks after operation. Sulfadiazine was given in sufficient amounts to maintain a high concentration in the blood during this time.

Recovery was uneventful. However, five years later, puffiness of the left eyelid occasionally appeared in the mornings during head colds, and there was a periodic purulent discharge from the frontal sinus.

The diagnoses were (1) acute infection of a mucocele (pyocele) of the left frontal sinus and (2) extradural abscess of the left anterior cranial fossa.

### MUCOCELE AND PROLIFERATIVE OSTEOMYELITIS

The occurrence of a mucocele along with the extensive proliferation of new bone is not unusual. In the past it was generally thought that in such cases an osteoma of the sinus had caused blockage of the nasofrontal duct with resulting mucocele or that possibly the development of the mucocele and the osteoma were independent. In some instances the history and clinical findings seem to indicate that the proliferation of bone has been secondary to the inflammatory process. Maxwell [11] recently presented a series of 8 cases of chronic proliferative osteomyelitis of the skull, in 6 of which the condition was secondary to sinus infections. A mild degree of chronic proliferative osteomyelitis is illustrated by case 3 (fig. 6*A*).

Case 5 in this series is presented as an example of extensive proliferation of new bone along with an infected mucocele. The widespread distribution of the new bone within the sinus and the dissemination of the purulent discharge in pockets throughout the new bone indicated that the osteogenic process was secondary to the inflammatory reaction. In this case proliferative osteomyelitis seemed the correct interpretation on clinical observation. The histopathologic observations supported this diagnosis.

11. Maxwell, J. H.: Chronic Proliferative Osteomyelitis of the Skull, Ann. Otol., Rhin. & Laryng. **55**:719-742 (Dec.) 1946.

Case 5.—M. C., a woman aged 46, when first seen by us on April 6, 1946, stated that she had been struck on the forehead by a door eight months previously. Three months later she had noted a swelling over the right frontal area and of the right upper eyelid and for the past month had had an aching pain in that area. She had no nasal discharge.

On examination the bone over the right frontal sinus was tender and bulged considerably. A smooth, elastic, tender mass was palpable beneath the right supraorbital ridge and displaced the eye downward and laterally.

Roentgenologic examination showed evidence of pronounced sclerosis of the right frontal sinus. The peripheral margins of the sinus throughout appeared hazy and sclerotic (fig. 7 *A*). The pain and tenderness in that region subsided on administration of 1 Gm. of sulfadiazine four times a day.

An external radical frontal sinusotomy was performed on the right side on April 24. The frontal bone was found to be considerably thickened. A large mass

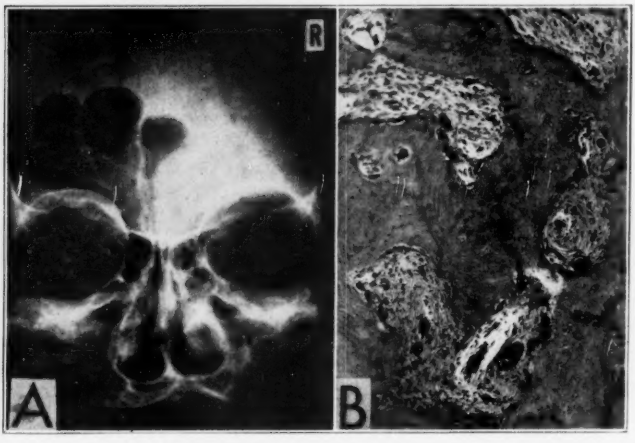


Fig. 7.—*A* (case 5), mucocele of the right frontal sinus associated with chronic proliferative osteomyelitis of the frontal bone. The cyst had expanded into the orbit. It contained mucopus and a mass of new bone. *B*, photomicrograph of new bone removed from the frontal sinus in case 5. The bone trabeculae are lined with osteoblasts. Between the bone trabeculae is a vascular fibrous tissue richly infiltrated with small round cells.

of soft cancellous bone almost filled the sinus and appeared to be attached on wide bases to both the anterior and the posterior wall. Over the entire extent of the sinus walls was a soft layer of new bone, which was scooped out with a large bone curet. Small pockets of pus were dispersed throughout this new bone. The rest of the sinus was filled with mucopus. The cyst protruded into the orbit through a defect in the floor of the sinus. The anterior third of the middle turbinate body was amputated; the anterior ethmoidal cells were removed, and a wide opening was made into the nose.

There was diplopia on left lateral gaze for about five months after operation. When last seen by us, one year after operation, the patient was free of symptoms, and the right eye had returned to its normal position.

The diagnosis was chronic infection of a mucocele in the right frontal sinus with chronic proliferative osteomyelitis of the frontal bone. (A microsection of the new bone growth is seen in fig. 7 *B*.)

## ODONTOGENIC CYSTS

A review of dental embryology is presented for the purpose of clarifying the histogenesis of follicular and radicular cysts.

Tooth development begins by extension of the dental lamina down into the primitive gum, where knoblike thickenings occur. These form into inverted cup-shaped structures, having an inner and an outer enamel epithelium, separated by a filling of looser cells, the stellate reticulum (fig. 8*A*). Specialized connective tissue cells, the odontoblasts, arise from the thickened mesenchyme beneath the deeper side of the enamel organ and are concerned with the formation of dentine. Then, as enamel is laid down on the dentine, the stellate reticulum disappears, and the outer enamel epithelium loses its separate identity.

Follicular cysts develop from enamel organ epithelium around the crown of the tooth. The cause of the development of the cyst is not definitely known. One theory is that it forms by dissolution of the stellate reticulum and distention of the dental follicle.

As the tooth develops, there is a downward extension of the enamel epithelium over the upper part of the dental papilla, thus forming Hertwig's sheath (fig. 8*B*). It has conclusively been shown that remnants of this epithelial sheath may persist in the periodontal membrane after tooth development is completed. The epithelium in an apical granuloma is probably derived from these cell nests (debris of Malassez). Inflammatory stimulation causes the epithelium to proliferate in the form of strands, which may ramify in the granulation tissue (fig. 9*A*). The tendency of the epithelium to grow on a surface often results in its forming a complete lining of an abscess cavity.

Radicular cysts may develop from these apical granulomas; whether or not these cysts have an epithelial lining depends on whether or not epithelial rests have been caught in the granuloma (fig. 9*B*).

The formation of a cyst depends on the following factors: (1) central dissolution of the granuloma, (2) transudation of fluid through the cyst wall, (3) absence of spontaneous drainage by formation of a fistula and (4) a mild clinical course without surgical intervention.

### FOLLICULAR CYST

The follicular cyst is derived from enamel organ epithelium and usually contains the crown of a tooth in its wall. It occurs more frequently in the mandible than in the maxilla. This cyst may arise from any of the permanent or deciduous teeth but has origin most commonly in the enamel organ of the third molar. When a tooth is present in its

wall, the cyst is commonly termed a dentigerous cyst. Occasionally there are multiple cysts or multiple teeth in one cyst. There will be no tooth in the cyst wall if the cyst develops from the enamel epithelium before it has become sufficiently differentiated to form enamel.[12]

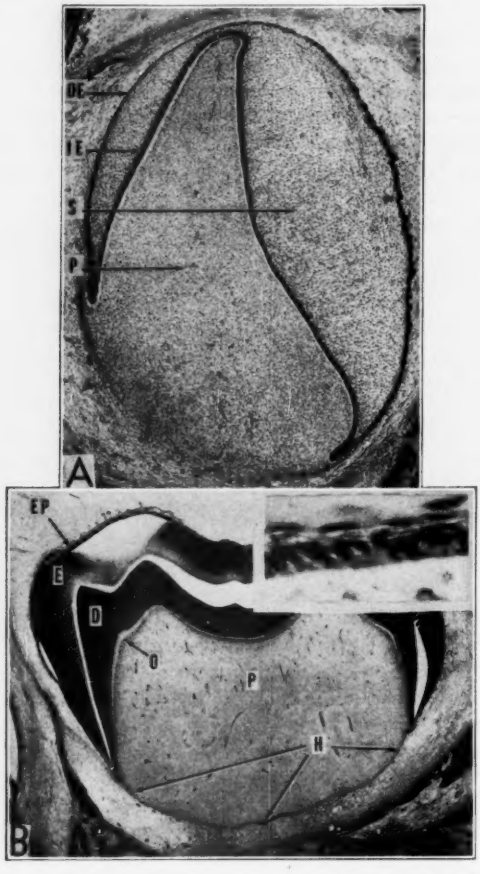


Fig. 8.—*A*, an early tooth bud in a newborn infant. *OE* signifies the outer enamel epithelium; *IE*, the inner enamel epithelium; *S*, the stellate reticulum and *P*, the dental papilla. *B*, a developing molar in a 4 month old infant. *EP* signifies enamel epithelium; *D*, dentine; *E*, enamel; *O*, odontoblasts; *P*, dental papilla, and *H*, Hertwig's sheath. Inset, a high power view of the epithelium of Hertwig's sheath.

12. Thoma, K. H.: Oral Pathology: A Histological, Roentgenological, and Clinical Study of the Diseases of the Teeth, Jaws, and Mouth, St. Louis, C. V. Mosby Company, 1941.

The cause of this maldevelopment of the dental follicle is not known.

*Pathologic Factors.*—The cyst wall consists of a connective tissue capsule, of varying density, and a lining of stratified squamous epithelium. There is usually an infiltration of small round cells into the sub-

Fig. 9.—*A*, an epitheliated apical granuloma. *R* signifies the tooth root; *G*, the granulation tissue, and *C*, a small cystic space lined with epithelium. *B*, a nonepitheliated apical granuloma. *G* signifies the fibrosing granulation tissue, and *C*, the nonepitheliated cystic space.

epithelial connective tissue. When a tooth is present, the epithelium is usually attached to the neck of the tooth, with the crown projecting into the contents of the cyst. As the follicle expands, the tooth may be

displaced far from its original site. It was shown by Cahn [13] that there may be transition from this simple odontogenic cyst to adamantoblastoma.

*Symptoms.*—There often are no symptoms until the cyst is so large as to cause deformity of the alveolar process, palate or face. Pain, if present, is usually minimal and, when due to pressure on nerves, may be referred to other parts of the face.

The cyst may invade, completely fill and expand the walls of the maxillary sinus. The cyst may become infected.

*Clinical Findings.*—Facial or nasal deformity may occur when the follicular cyst is so large as to fill the maxillary sinus and expand its walls. An additional clinical finding in some cases is the absence of a tooth on the involved side.

The typical roentgenologic picture of the alveolar process is that of a rounded area of destruction of bone with smooth borders and containing a tooth. When the antrum is involved, a shadow of increased density is seen to bulge up from the floor. The tooth, when present, is often displaced into the sinus. As the follicular cyst becomes larger, one or more of the bony sinus walls may become thin, smooth and expanded.

*Treatment.*—The treatment is complete surgical removal of the follicular cyst and its contents. Care should be used in removing all the cyst wall, as it may be adherent to the bony wall of the sinus in some areas. The removal is usually best accomplished by the Caldwell-Luc operation.

CASE 6.—H. G., a man aged 20, complained only of recent pain in the right side of the face. Clinical examination revealed a bulging inward of the lateral wall of the right nasal passage. The right third molar tooth had not erupted.

Roentgenologic examination revealed complete clouding of the right maxillary sinus. A shadow having the general contour of a tooth lay in the posterolateral angle of the sinus (fig. 10 *B* and *C*).

A radical antrotomy was performed on the right side. The bony wall in the region of the canine fossa was thin. The cyst wall was tough and under tension. It was needled, and 20 cc. of thick viscid material was removed. The wall of the cyst was adherent to the floor. A large tooth projected into the cyst from the posterolateral wall near the floor. It was removed with the cyst wall without difficulty. There was no bone in the nasoantral wall below the inferior turbinate process. A large window was made into the nose through the inferior meatus. A section through the wall of the cyst is seen in figure 10 *A*.

The diagnosis was a follicular (dentigerous) cyst of the right third molar tooth, filling the right maxillary sinus.

### RADICULAR CYST

The radicular cyst develops at the root of a tooth, in contradistinction to the follicular cyst, which develops around the crown. As

13. Cahn, L. R.: The Dentigerous Cyst as a Potential Adamantinoma, Dent. Cosmos **75**:889-993 (Sept.) 1933.

previously stated, the radicular cyst probably develops from central necrosis of an apical granuloma. The occurrence of an apical granuloma secondary to infection of the pulp canal is common. When the acute inflammatory reaction is mild, the condition may go untreated and the granuloma increase in size. Central dissolution may take place by abscess formation or possibly may be due to a vascular disturbance.

*Pathologic Factors.*—Occasionally the centrally degenerated apical granuloma will proceed to formation of a cyst if not interfered with. Epithelial rests from Hertwig's sheath may be caught in this granuloma and under stimulus will partially or completely line the cystic space. The epithelium is the stratified squamous type and closely resembles oral

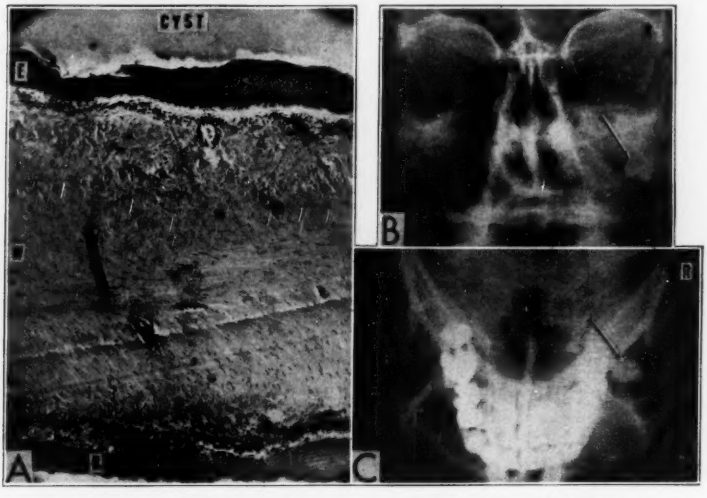


Fig. 10.—*A*, wall of a follicular cyst (case 6). *E* indicates stratified squamous epithelium lining the cyst; *W*, dense fibrous tissue wall, and *B*, a small sliver of bone from the surrounding bony wall. *B*, follicular cyst of the right maxillary sinus (case 6). The tooth has been displaced into the posterosuperior aspect of the right maxillary sinus (arrow). *C*, axial view (case 6). The arrow indicates a tooth.

epithelium. As stated before, whether or not radicular cysts are epithelized depends on whether or not paradental epithelial debris is present. The cyst fluid consists of inflammatory exudate, necrotic tissue and cholesterol crystals. The wall consists of a connective tissue stroma of varying density, richly infiltrated with small round cells and some small blood vessels. The degree of cellular infiltration and fibrosis of the cyst wall is determined by the amount of inflammatory reaction and the age of the cyst. As the cyst expands, resorption of

bone takes place. Outside this zone of bone resorption, however, new bone is usually laid down, so that as the cyst bulges up into the antrum a thin shell of bone may cover it.

*Symptoms.*—Symptoms are usually minimal; however, there may be toothache and pain over the side of the face. As the cyst expands downward through the alveolus, a tender swelling of the gum may result. Rupture may occur, with drainage of the contents of the cyst into the mouth. The cyst may develop after the offending tooth has been removed. One might assume that in such a case an infected root

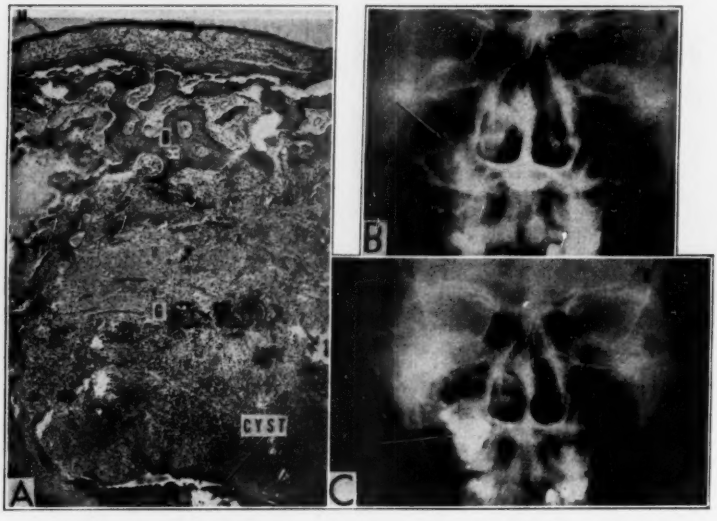


Fig. 11.—*A*, wall of a radicular cyst (case 7). *M* indicates the mucosa of the maxillary sinus; *B*, the bony capsule, and *G*, granulation tissue. *B*, radicular cyst (case 7). There is a dense shadow extending from the alveolar process up into the left maxillary sinus (arrow). *C*, roentgenogram in the same case, with iodized oil U.S.P. outlining the cystic space.

fragment had been left in the alveolar process or that a pyogenic granuloma had persisted after extraction of the tooth.

*Clinical Findings.*—Swelling and tenderness over the involved maxillary sinus or of the gum may be present. Dental roentgenograms reveal the round area of bone destruction in the alveolar process, usually around the root of a tooth. When the antrum is involved, roentgenograms of the sinuses reveal a dense, homogeneous shadow bulging up from the floor. This shadow may be so large as to involve the entire sinus.

*Treatment.*—Offending teeth which remain should be extracted. It is essential to remove all diseased tissue from the alveolar process. If the maxillary sinus is infected or extensively occupied, it should be exenterated, for which procedure a Caldwell-Luc approach is most suitable. Care should be taken to create a nasoantral window which will remain open.

CASE 7.—M. K., a woman aged 40, complained of pain and swelling, of three days' duration, in the region of the left cheek. All the left upper teeth had been removed one year previously, without event. Examination revealed tenderness and puffiness of the left cheek over the left maxillary sinus. There was a red, tender and fluctuant mass, the size of a hazelnut, on the buccal aspect of the gum in the left upper premolar region. Purulent material was aspirated and iodized oil U.S.P injected into the cyst.

Roentgenograms revealed a poorly defined mass extending from the floor up into the left maxillary sinus. Injection of iodized oil U.S.P. outlined a large cyst extending from the alveolar process up into the sinus (fig. 11 *B* and *C*).

One month later, with the use of local anesthesia, a mucoperiosteal flap was raised to uncover the left alveolar process in the area from the first bicuspid to the third molar. The wall of the cyst was dense and adherent to the floor. There was only a thin shell of bone over the dome and the lateral walls of the cyst. The cyst was completely removed by curettage.

A photomicrograph of the cyst wall is seen in figure 11 *A*. In this case the cystic space was not epithelized.

The diagnosis was a radicular cyst invading the left maxillary sinus.

## SUMMARY

Benign cysts of the paranasal sinuses may be divided into two groups, those arising from the sinus mucosa and those of dental origin.

Three types arise from sinus mucosa:

1. Nonsecreting cysts, found in the maxillary sinus. They arise in the connective tissue layer as a result of chronic inflammation and contain straw-colored fluid of high protein content. As they become large, both local and general toxic symptoms may be produced. They have a thin wall and rupture before causing deformity.

2. Small retention (glandular) cysts. These are common in hyperplastic sinus mucosa and are probably due to obstruction of the duct by hyperplastic epithelium. They occur as part of the pathologic process in chronic inflammatory disease of the sinuses; they are not individually evident in roentgenograms but may be seen during surgical removal of the mucosa.

3. Mucoceles. These are commonly found in the frontal and ethmoidal sinuses. They are apparently due to obstruction of the outlet of the sinus into the nose. They erode the bony walls and may produce facial deformity.

Benign cysts of dental origin which may involve the maxillary sinus are as follows:

1. Follicular cysts. These arise from the enamel organ epithelium, may or may not contain teeth, may encroach on the maxillary sinus and nasal cavity and may produce external deformity.

2. Radicular (root) cysts. These develop from apical granulomas and may or may not have an epithelial lining.

The microscopic sections for figures 8 and 9 were supplied by Dr. James R. Blayney, Zoller Dental Laboratory, the University of Chicago.

# MIXED TUMOR OF THE REGION OF THE HEAD

DAVID P. CORDRAY, M.D.
BOSTON

THE TERM "mixed tumor" has appeared in the literature and has been used in general discussions of tumors of the region of the head for years. Because of the partial misnomer, "mixed," the nature and the characteristics of the tumor have become confused, and an approach to the problems which cases of tumor of this type present has, on some occasions, not been clearcut. The tumor has been found in the salivary glands, the buccal mucosa, the palate, the lips, the neck, the orbit, the lacrimal gland and the face. However, the term is also used to include any tumor in any other part of the body which contains comparatively simple, chiefly embryonal growths of purely local origin, resulting from an overgrowth of embryonal structures with or without displacement. Most of the accepted forms of the tumor do not contain derivatives of the three germ layers, but are bidermal or monodermal. According to this concept, teratoma obviously falls into this group, but Ewing [1] has stated that the term "teratoma" should be used when the structure is more complete and rudimentary organs are present. Hence, by generally accepted definition, a mixed tumor is a complex embryonal tumor of local origin which reproduces the normal development of the tissues and organs of the affected part. It was recognized as early as 1879 that this type of tumor is of a highly complex structure. It usually presents epithelial elements in the form of cell strands, alveoli or diffuse masses, and mesoblastic tissues—chiefly cartilage and mucous and cellular connective elements. Any one of these tissues may predominate and give a nearly pure chondroma, sarcoma or carcinoma, but usually all the cell types are present.

In a series of studies Krompecher [2] reached the conclusion that the mixed tumor of the salivary gland belongs to a class of basal cell carcinomas. In the soft, pliable stroma of the growth he found that the

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From the Department of Otolaryngology, Massachusetts Eye and Ear Infirmary.

1. Ewing, J.: Neoplastic Diseases: A Treatise on Tumors, ed. 3, 1928, Philadelphia, W. B. Saunders Company, p. 773.

2. Krompecher, E.: Beitr. z. path. Anat. u. z. allg. Path. **28**:1-41, 1900.

epithelial cells readily split off, fibrillate and assume the spindle or the star shape of mucoid or embryonal connective tissue cells. Under these conditions true connective tissue and, by further metaplasia, cartilage may be derived from basal epithelium.

Briefly, the present status of knowledge concerning the mixed tumor of the salivary gland, according to Ewing,[3] may be summarized as follows:

1. The theory of strict endothelial origin has been disproved.

2. No single source of the mixed tumor meets all the requirements. In some instances it is distinctly adenomatous and probably arises from the acini and ducts of the glands in which it is well incorporated. In still other cases it is encapsulated or extraglandular and takes the form of basal cell epithelioma. Probably in these instances it arises from misplaced and occasionally embryonal portions of gland tissue. Branchial remnants may possibly be connected with this group.

3. That mucous tissue and cartilage may derive from gland epithelium has been satisfactorily proved, and there is no necessity of including in the primary tissue any cartilaginous structures.

### ANATOMIC ASPECTS

The gross anatomy presents many variants. The usual beginning is a small firm nodule in or on the salivary gland, a nodule which remains within a well defined capsule until it reaches considerable size. Fusion with the septums of the gland is commonly observed, and in the lobulated tumor the dividing trabeculae may be continuous with the interlobular septums. If small, the tumor may be completely separable; if large, it shows increased fusion, or it may be incorporated in the gland from the onset. Only occasionally is it possible to excise the tumor without including fragments of the gland. Frequently there is no obvious connection between the tumor and any gland. In some instances it develops along Stensen's duct; in others it may appear below or behind the ear and seem to involve the aural cartilage, while in a few cases it is found well below the submaxillary gland. It may appear in the retropharyngeal region or in any part of the lateral wall of the pharynx or the floor of the mouth. In consistency it is usually quite firm, but the cellular and mucoid type of growth may be soft and elastic. Small cysts are frequently encountered, and very rarely the tumor may consist of one large cyst. Cross section reveals opaque cellular areas, which may be vascular, softened, gelatinous masses, exuding mucus or serum; likewise, hard fibrous or hyaline zones or areas of cartilage and,

3. Ewing,[1] p. 775.

very rarely, bone are seen. In almost all instances the tumor shows evidence of mucous secretion. Predominance of one element may give an almost pure myxoma, chondroma, fibroma, carcinoma or sarcoma.

### CLINICAL COURSE

It is obvious both from reports in the literature and from clinical observation that in the vast majority of cases an observable but small tumor has long preceded the period of active growth. In our series there was an average period of quiescence of seven years. It is interesting to note that Wood [4] reported an inactive period of fifty-three years in a case which he observed. Following the initial appearance and quiescence, the tumor enters on a stage of active growth. The speed with which the mass increases in size is apparently dependent on the histologic type, although a limitless growth is not necessarily an attribute of this tumor, since it may continue to increase in size for several years and then enter another quiescent stage.

The only constant factor in the clinical behavior is, paradoxically, the wide variation in the cycle of growth, which is unpredictable. Occasionally, the growth is steadily progressive and rapid, highly infiltrative and possessed of all the characteristics of cancer. Fortunately, the incidence of this type is low. At the other end of the growth spectrum are those forms which remain encapsulated and the growth of which is such a slow process that the patient lives a normal span of life and dies of other, unrelated pathologic conditions.

When a mixed tumor has reached sufficient size, its presence is known by two factors: (1) pressure phenomena and (2) cosmetic distortion. Since the facial nerve lies below the parotid gland and in this region the incidence of the tumor is 51 per cent of those studied, it would be reasonable to assume that the facial nerve should show distortion of function in a high percentage of cases. This, however, is not a demonstrable fact, the incidence in the series observed at the Massachusetts Eye and Ear Infirmary being only 0.1 per cent of cases. But involvement of this nerve is a constant potential danger, though fortunately it takes place quite slowly. The undisturbed tumor rarely invades the lymph nodes, but after an unsuccessful operative procedure, while the recurrence is usually local, the regional glands may become involved. As do many other types of tumor, the mixed type most frequently manifests itself by anatomic distortion, and it is this symptom alone which causes the patient to consult the physician.

One fact concerning the clinical course is most significant—no patient complains of pain.

4. Wood, F. C.: Ann. Surg. **39**:57 and 207, 1904.

### INCIDENCE

During a period of ten years 61 patients were operated on for mixed tumor in the Tumor Clinic of the Massachusetts Eye and Ear Infirmary and Massachusetts General Hospital. An analysis follows.

Total cases of mixed tumor—61
- Cancerous ..... 7
- Noncancerous .....54

Position of tumor—
- Parotid gland.....30
- Submaxillary region... 8

(Massachusetts General Service.....20; Massachusetts Eye and Ear Infirmary Service .....10)

- Palate ..... 7
- Lacrimal gland..... 3
- Jaw ..... 3
- Tear sac..... 2
- Neck ..... 2
- Tongue ..... 2
- Cheek ..... 2
- Tonsil ..... 1
- Pharynx ..... 1

### COMPLICATIONS

The facial nerve was involved prior to operation in 2 cases and after operation in 7; there was weakness, not complete paralysis, in the distribution of the branches of the nerve. There was recurrence in 4 cases —in all of which the tumor was noncancerous. There was no case in which salivary fistula developed.

### TREATMENT

In theory the prognosis following treatment should be excellent, because of the fact that the tumor is so predominantly benign. However, the facts do not uphold this theory, primarily because the treatment afforded the mixed tumor has had little or no plan, has been inadequate or has been directed along the wrong path of attack. Roentgen ray treatment is a glaring example of the latter. In spite of many articles condemning this practice, one finds in certain places a reliance on this therapy. Roentgen therapy for the mixed tumor should be thoroughly condemned for two reasons: First, the tumor is highly resistant to radiation, and hence no real effect is secured; second, the consequent fibrosis, induced by the roentgen rays, causes difficulty without end for the surgeon when finally the patient submits to operation.

If the tumor involves structures about the head and neck other than the parotid gland, its removal is generally attended by no great difficulty and, as a rule, falls into the classification of routine procedures. If the tumor involves the parotid gland, however, it is in another category

because of the anatomic relationship between the gland and the facial nerve. In attacking any problem involving a tumor, the primary purpose of the surgeon is to excise completely or eradicate all tumor cells; for, if this is accomplished, absolute cure is established, at least in theory. My associates and I believe that this should be kept in mind at all times, particularly in relation to the parotid gland. Because the facial nerve is in close proximity, much incomplete surgical intervention has been done, and the recurrence rate for a normally benign tumor of this region is absurdly high—as much as 20 per cent (Ahlbom [5]) in some series. Why is it that the recurrence rate in other sites is very low? The answer must be in two words—complete excision. It appears that if this is to be accomplished the surgeon must direct his efforts toward this end in spite of the barrier of the facial nerve.

In general the cases may be grouped clinically as instances of the encapsulated and instances of the infiltrated type. With the encapsulated type the usual mode of attack is to evacuate the content and go no further. It is important to remove the capsule completely and to avoid scattering tumor cells in the exposed area. Bailey [6] advised flooding the wound with 60 per cent alcohol before closure in order to destroy cells which may become centers of recurrence. As a rule this type presents no great difficulty with branches of the facial nerve. Nevertheless, any suspicious structures may be pinched gently, and if facial twitching results, severely isolated.

The infiltrative type, with fibrous strands merging with gland tissue and muscle, has always presented the problem of possible facial paralysis when surgical excision is performed. This no doubt accounts for the incomplete removal and subsequent recurrence. On several occasions various authors have suggested that when the tumor is of this character a complete parotidectomy be performed (Bailey; [6] Patey [7]). However, this advice is not generally followed, possibly because of a misconception concerning the surgical anatomy of the parotid gland and the facial nerve. One point should be emphasized, namely, that the facial nerve does not pass within the actual substance of the gland; its main divisions lie between the deep and superficial lobes. However, because of the small size of the deep lobe, the outlying subdivisions of the nerve rest between the superficial lobe and the masseter muscle. The entire gland may be removed and the facial nerve remain uninjured if adequate exposure and careful dissection are employed.

To recapitulate, treatment consists of complete excision of the encapsulated type, with great care being taken to remove the capsule, and

5. Ahlbom, H. E.: Acta radiol., 1935, supp. 23, pp. 1-452.
6. Bailey, H.: Brit. J. Surg. **28**:337-346 (Jan.) 1941.
7. Patey, D. H.: Brit. J. Surg. **28**:29-38 (July) 1940.

complete removal of the gland when the tumor is of the infiltrative type or variety.

## SUMMARY AND CONCLUSIONS

The mixed tumor is composed of complex embryonal cells of local origin which reproduce the normal development of the tissues and organs of the affected parts. The tumor may appear in any portion of the neck or the face, but in 50 per cent of the cases it occurs in the parotid gland.

The growth is slow, with periods of quiescence followed by activity.

Sixty-one cases are analyzed as to the site and the type of the tumor and as to recurrence.

The treatment, both proper and improper, is outlined.

403 Commonwealth Avenue.

# Case Reports

## PNEUMOCOCCIC MENINGITIS

### Presentation of a Case with Operation and Recovery

JACK H. FOERTSCH, M.D.
AND
ARTHUR J. FISCHER, M.D.
PITTSBURGH

WE BELIEVE that the classification of cases of otitic meningitis presented by Kerrison [1] is the simplest, yet the most inclusive. He divided cases of otitic meningitis into those of circumscribed pachymeningitis and those of leptomeningitis.

Most aural surgeons have encountered circumscribed pachymeningitis accidentally during a mastoidectomy. The dura alone is inflamed and edematous, without the underlying structures being disturbed. The inflammation usually subsides promptly after removal of the surrounding necrotic bone. However, it undoubtedly is the precursor of more serious lesions.

The cases of leptomeningitis, which involves the pia and the arachnoid as well as the dura, were further subdivided by Kerrison into those of diffuse purulent, those of circumscribed purulent and those of serous leptomeningitis.

Diffuse purulent leptomeningitis is a suppurative inflammation of the meninges which has reached the subdural and subarachnoid spaces. The infection has spread widely, and there is no tendency on the part of the meninges to form limiting peripheral adhesions. Thus it is unavoidably accompanied by cortical encephalitis. Pus and bacteria are encountered in the spinal fluid, and, if one is to be certain of the diagnosis, the organisms must grow on culture.

Circumscribed purulent leptomeningitis is also a suppurative inflammation of dura, pia and arachnoid, but it is confined to a distinctly limited area by adhesions which bind the arachnoid and the pia to the dura and to the brain substance itself. However, there is never any assurance that the infection might not break its bounds and develop into the diffuse type or into an abscess involving either the temporal lobe of the cerebrum or the cerebellum.

Serous leptomeningitis also involves dura, pia and arachnoid, but no organisms can be found in the spinal fluid, although the meninges are congested and edematous.

There are a number of ways in which infection travels from the ear to the brain. The most common is by extending directly through the necrotic bone of the tegmen. Suppurative labyrinthitis may spread through the saccus endolymphaticus or through the aquaeductus cochleae and infect the meninges. Retrograde thrombophlebitis may involve

Read before the Staff of St. Francis Hospital, Sept. 8, 1947.

1. Kerrison, P. D.: Diseases of the Ear, ed. 3, Philadelphia, J. B. Lippincott Company, 1923, pp. 382-393.

the meninges via the vessels that run from the mastoid process to the dura. Infection may also travel through the nerves leaving the internal auditory canal. According to Lederer,[2] the lymphogenous route is a possibility. He claimed that in severe streptococcic infections purulent material passes through the marrow spaces to the meninges.

The classic symptoms of meningitis are well known and need no further coverage here. However, Lederer described what is called a hood type of meningitis which may arise from otitic infection. In this condition, only the convexity of the brain is involved; thus there would be no nuchal rigidity and subsequently no Brudzinski, Kernig or Bondy signs.

## REPORT OF CASE

*History.*—Mr. H., a 47 year old white man, was brought to the hospital emergency room in a stuporous condition on April 14, 1947. His son provided the following information. There had been no previous history of ear trouble except that several years ago he refused to go swimming because of some vague ear complaint. Three days prior to admission he was seen by his family physician because of pain in his right ear. He was afebrile, and there was no discharge of the ear. Penicillin orally and heat in the form of a hot water bottle were prescribed. There was no progression of symptoms until the day of admission, when he complained of severe generalized headache, was feverish and vomited on several occasions. At approximately 1 p. m. he suddenly became stuporous and was again seen by his family physician, who promptly sent him to the hospital with a diagnosis of meningitis. On arrival at the emergency room he was delirious and restless and violently resisted examination. He would not respond to questioning.

*Physical Examination.*—His temperature was 103 F.; the right pulse rate was 88; the respirations were 24, deep and stertorous. The blood pressure was 150 systolic and 70 diastolic. His skin was hot, sweaty and flushed. Marked nuchal rigidity was present. There was a positive Kernig sign bilaterally. The Brudzinski sign was present. All extremities were flaccid, but passive motion was impeded. The reflexes were not exaggerated, and the Babinski sign was absent. Eyes, nose, chest and abdomen revealed nothing of note.

It was rather difficult to examine the ears because of the inability of the patient to cooperate. The left drum was intact, but was thick, dull and retracted and presented a large calcareous plaque in the anterior inferior quadrant. The right external auditory canal was filled with thick purulent material, which was definitely coming from the middle ear. There was a fulness in the attic area.

*Roentgen Findings.*—The roentgen plates were not too satisfactory because of the inability of the patient to cooperate. However, they did show a tendency toward sclerosis on the right, with some pneumatization beneath a rather thick cortical plate. There was a fuzzy exaggeration of the cell walls. The findings were indicative of acute mastoiditis on the right side.

*Laboratory Findings.*—A spinal tap was performed in the emergency room, followed by withdrawal of 8 cc. of turbid fluid, the supernatant layer of which was yellow. The initial pressure was 500 mm. of water, and the final pressure was 380 mm. There were 22,848 cells, 95 per cent of which were polymorphonuclear

2. Lederer, F. L.: Diseases of the Ear, Nose and Throat: Principles and Practice of Otorhinolaryngology, ed. 2, Philadelphia, F. A. Davis Company, 1939, pp. 191-193.

leukocytes and 5 per cent lymphocytes. The fluid was so filled with organisms that the laboratory was able to obtain type V pneumococci by direct Neufeld typing. Culture of a blood specimen taken at this time also revealed type V pneumococci, as did culture of the material from the right external auditory canal. The blood count showed 35,750 white blood cells of which 60 per cent were segmented cells and 35 per cent band cells of the granulocytic series; the remaining 5 per cent were lymphocytes. The subsequent laboratory work is summarized on chart 1.

*Treatment.*—Because of the accumulated findings, it was decided to operate immediately. The patient was taken to the operating room under the influence of tribromoethanol solution U. S. P. Fifty thousand units of pencillin dissolved in 3 cc. of sterile distilled water was administered intrathecally just prior to operation. Intravenous administration of 37½ grains (2.43 Gm.) of sodium

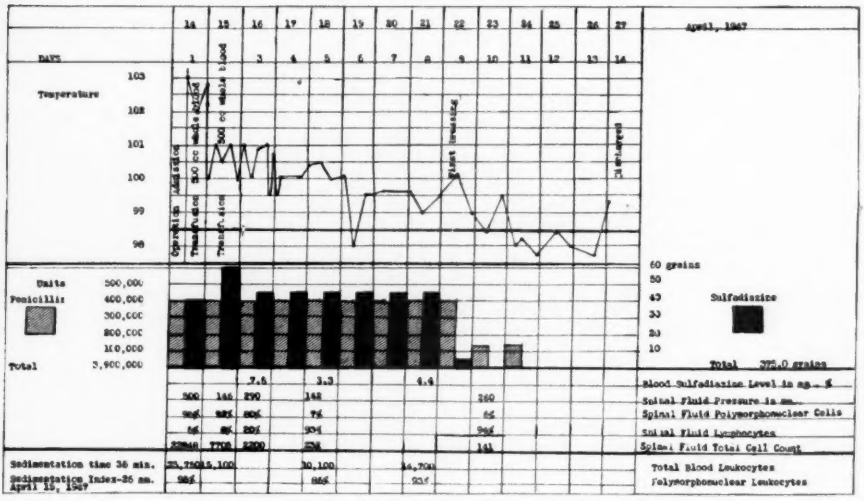


Chart 1.—Clinical-therapeutic log of the patient.

sulfadiazine and 300,000 units of penicillin dissolved in 1,000 cc. of isotonic solution of sodium chloride was started. Ether anesthesia was administered approximately two and a half hours after admission. The type of operation to be performed presented no easy problem. It has been advocated that when operating on an acutely diseased ear one should perform the simple mastoidectomy, and when operating on a chronically diseased ear, the radical mastoidectomy. We were not certain whether the patient's condition was the result of acute otitis media or the result of acute exacerbation of chronic suppurative otitis media. It was decided that the safest procedure would be to perform a modified radical mastoidectomy of the Bondi type, in which the facial bridge is broken down but the pars tensa is preserved, so that if the patient recovered, a certain amount of hearing might be preserved. A postauricular incision was made. The cortex was found to be densely sclerotic and thick. Underneath, only diploic structures were

encountered. It was rather gratifying to find a large area of necrotic bone in the region of the mastoid tegmen. This was thoroughly removed and an area of dura approximately 2 cm. in diameter was exposed. The dura was purplish and edematous but not tense. We could find no opening into the subdural space. We did not incise the dura. A Siebenmann flap was prepared, a split skin graft on a paraffin gauze mold was inserted into the cavity, the postauricular wound was closed completely with interrupted black silk sutures, and the cavity was drained with a loosely packed strip of iodoform gauze. The patient left the operating room in only fair condition.

The first postoperative day was rather a stormy one; however, by 8 p. m., thirty hours after admission, he was able to answer questions fairly intelligently. He was even able to take fluids by mouth. His restlessness was easily controlled by small doses of morphine. The temperature fell by lysis, and his progress was uneventful, with no tendency toward the relapse for which pneumococcic meningitis is well known. On April 27, after having completed thirteen days of hospitalization, he was discharged. At that time the postauricular wound was completely healed and there was only a small amount of material draining from the external canal. He was rather deaf, but his greatest complaint was an annoying tinnitus.

Office treatment was directed at simple cleansing of the cavity and catheterization of the eustachian tubes. An audiogram on May 12 showed an average decibel loss of 55 for the left ear and 80 for the right ear. On May 22 the loss was 50 decibels on the left and 65 decibels on the right. By August 4 the loss was 37 decibels on the left and 63 decibels on the right. At the time of writing the cavity is completely epithelized and dry. The left drum membrane, although somewhat thick, shows a fair cone of light and good luster. The Weber test sound is lateralized to the right. The Rinne test shows sound heard better by bone than by air conduction on the left and the reverse on the right. Tests showed hearing loss for all C forks in both ears. His only complaint is a rather annoying tinnitus, which is worse at night and during hot humid weather.

### INTRATHECAL PENICILLIN THERAPY

The advisability of administering penicillin intrathecally was a problem in our minds because of the various reports in the literature of paralyses developing from this therapy. Sweet and associates [3] reported 2 cases in which a neurogenic disturbance of the bladder developed which persisted for more than two weeks. Siegal [4] observed a patient in whom transverse myelopathy developed. Other workers have reported the development of paraplegia, convulsions and persistent headache.

Rammelkamp and Keefer [5] have shown that intrathecally injected penicillin diffuses throughout the ventriculosubarachnoid space and that significant amounts remain in the spinal fluid for twenty-four hours. They have also shown that even with a solution containing not more than 1,000 units per cubic centimeter intrathecal injection is usually fol-

3. Sweet, L. K.; Dumoff-Stanley, E.; Dowling, H. F., and Lepper, M. H.: The Treatment of Pneumococcic Meningitis with Penicillin, J. A. M. A. **127**:263-267 (Feb. 3) 1945.

4. Siegal, S.: Transverse Myelopathy Following Recovery from Pneumococcic Meningitis, J. A. M. A. **129**:547-550 (Oct. 20) 1945.

5. Rammelkamp, C. H., and Keefer, C. S.: The Absorption, Excretion and Distribution of Penicillin, J. Clin. Investigation **22**:425-437 (May) 1943.

lowed by pleocytosis of a considerable degree. (Note chart 1.) Penicillin when given intravenously or intramuscularly does not get into the spinal fluid in any significant amounts. The pleocytosis that occurred in our case after a single injection of penicillin was marked.

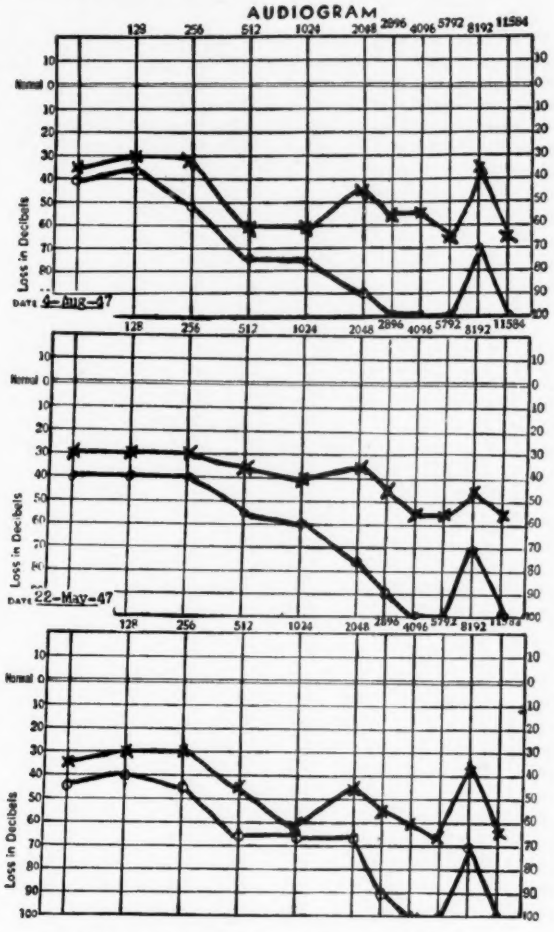


Chart 2.—Postoperative audiometric findings.

Multiple intrathecal injections of penicillin have been advocated in cases of pneumococcic meningitis. However, we decided on the single injection for three reasons: First, we were fearful of damaging the central nervous system; second, the clinical progress of our patient was

progressively for the better, and third, we hoped that the large initial dose might be adequate to nullify the effects of the pneumococci present.

We feel that had it not been for the availability of sulfadiazine and penicillin along with proper surgical intervention, our patient certainly would have died.

SUMMARY

A case of type V pneumococcus otitic meningitis with operation and recovery is presented. A large concentrated single dose of penicillin was administered intrathecally with no resultant injury of the central nervous system. We feel that surgical intervention was as necessary to this patient's recovery as was the administration of penicillin and sulfadiazine.

# Clinical Notes; New Instruments and Technics

## SIMPLIFIED PENICILLIN NEBULIZER APPARATUS

MERVIN C. MYERSON, M.D.
BEVERLY HILLS, CALIF.

MUCH has been written concerning aerosolizers for penicillin and other medicinal agents. All of the apparatus in use depend on the positive pressure of an oxygen tank to produce nebulization. In addition, a mask and a rubber bag are part of the equipment. The method which is the basis of this report depends

The simplified nebulizer. It is connected by the rubber tube with a source of compressed air.

on a small nebulizer which is connected by a rubber tube with a source of compressed air, either a tank or an electrically driven apparatus.

For some time I have been administering, in nebulized form, solutions of such substances as penicillin, streptomycin, sulfathiazole sodium, epinephrine hydrochloride, amphetamine and various antiseptic and oily mixtures for disease of the nasal and lower respiratory passages. When oil is used, sweet almond oil is

always the base. Oil is nebulized more rapidly than aqueous solution because of the greater viscosity, which offers more resistance to the stream of air, thereby causing greater diffusion.

When penicillin is used, 100,000 units is dissolved in 1 cc. of distilled water. This solution together with 3 cc. of sweet almond oil is introduced into the nebulizer. The agitation caused by the passage of the stream of air thoroughly admixes the aqueous solution and the oil. A visible mist is given forth when the compressed air passes through the nebulizer. The apparatus is then ready for use.

The nebulized medicament may be introduced directly into each nasal chamber by loosely inserting the open end of the nebulizer into the nostril. For treatment of the oral cavity or the pharynx, the open end of the nebulizer is held between the lips during quiet, effortless respiration. When the larynx, trachea or bronchi are to be treated the patient is instructed to inhale deeply.

The nebulizer requires no special space. Keeping it clean presents no problem. The flow of compressed air is controlled by a simple valve, so that the patient may discontinue treatment at will.

It is hardly necessary to mention the extreme simplicity of this form of treatment. It has a special appeal to children. The oxygen aerosolizing apparatus is cumbersome, space consuming and not without discomfort to the patient. Many children object to it. All of these objections are overcome when this simple nebulizer [1] is used.

416 North Bedford Drive.

1. This nebulizer is made by Parke, Davis & Company, for epinephrine inhalation.

# OTOSCLEROSIS

## An Index of the Literature, with Abstracts, for 1947

THIS is the fourth instalment of volume IV "Otosclerosis" to be issued by the Central Bureau of Research of the American Otological Society, Inc.[1] We have been able to obtain and abstract several heretofore unavailable articles in foreign literature. Included among the abstracts are some on correlated subjects investigation of which is encouraged by the Bureau.

As in previous instalments, the opinions of the authors are quoted without comment, and the selection of articles implies no endorsement or condemnation thereof. The titles are given in English and the names of the mediums of publication in the language of the original. Dr. Franz Altmann has continued to cooperate in the preparation and translations of the abstracts. Owing to the labor difficulties, this instalment has again been unavoidably delayed. We trust that it will be possible to publish the abstracts of the 1948 literature before the end of 1949.

The preponderance of articles on the fenestration operation continues. Although there is much repetition, we have endeavored to present fully all of the points of view. A reprint of this instalment, with index of authors according to subjects and perforated for loose-leaf binding in volume IV "Otosclerosis," may be obtained at cost ($1.00) from

EDMUND PRINCE FOWLER, M.D., *Editor*
140 East Fifty-Fourth Street, New York 22.

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1. The Central Bureau of Research (originally the Committee on Otosclerosis) of the American Otological Society, Inc., is constituted as follows: Board of Trustees of the Research Fund: D. Harold Walker, M.D., chairman, Boston; John R. Page, M.D., vice chairman, New York; Edmund Prince Fowler, M.D., secretary, New York; Wesley C. Bowers, M.D., New York; Marvin F. Jones, M.D., New York; J. Gordon Wilson, M.D., Chicago; D. E. Staunton Wishart, M.D., Toronto, Canada. Lay Advisers to the Board: E. Ericson, New York; Samuel Lloyd, New York. Consultants to the board: Madison Bentley, Ph.D., LL.D., professor of psychology emeritus, Cornell University; J. B. Collip, M.D., D.SC., F.R.C.P., F.R.S., professor of medical research, University of Western Ontario; Stacy R. Guild, Ph.D., Johns Hopkins; Oscar Riddle, Ph.D., LL.D., D.H.C., Plant City, Fla.; Philip E. Smith, Ph.D., professor of anatomy, College of Physicians and Surgeons, Columbia University. Treasurer: Walter C. Baker. Depositary: Guaranty Trust Company of New York. Office of the Secretary: 140 East Fifty-Fourth Street, New York 22.

**de Amicis, E.** The Regeneration of Bone Tissue After Experimental Injury of the Labyrinthine Capsule in Dogs, *Pract. oto-rhino-laryng.* **9:** 295, 1947.

The material which brings about the repair of experimental injuries of the labyrinth in dogs consists of bone and connective tissue. In this reparation the periosteum of the endocranium takes a greater part than the periosteum of the middle ear. The endosteum of the cavities of the labyrinth responds vigorously to trauma by filling the defects with newly formed bone. Besides the periosteum and the endosteum, osteoblasts which originate from the vascular channels in the bone take part in closing gaps in the capsule. Narrow fissures are filled for long distances with osteoid tissue formed by these osteoblasts. Where the latter are absent, the fissures are closed by connective tissue only or remain patent. Fissures in the region of the promontory lead to a free communication between the tympanic cavity and the inner ear spaces.

**Aubry, M.** The Surgery of Deafness, *Ann. d'oto-laryng.* **13:** 29, 1946.

The author reviews the history of the operation designed to aid the patient with otosclerosis. He mentions the fact that the shifting of the fistula toward the ampulla may lead to prolonged vestibular disturbances. The author has recently followed Lempert's fenestra novovalis technic, but he used the mobile acrylic stopple instead of cartilage. He feels that a final technic has not yet been developed.

An advantage of the operation over the use of a hearing aid is in the fact that "the progress of the deafness can be checked by the operation."

The author operates on patients who have a rapidly progressive impairment of hearing with well preserved function of the inner ear as determined by the bone conduction of frequencies 2048 and 4096. For other patients a hearing aid seems preferable.

**Aubry, M.** Preoperative Audiometry: Evaluation on the Operating Table of the Primary Gain in the Course of Fenestration, *Ann. d'oto-laryng.* **64:** 642, 1947.

The operations were performed with the patients under local anesthesia, and five audiometric curves were taken as follows:

1. On the operating table before surgical intervention had taken place. This curve is often not as good as the preoperative curves, owing to the effect of the preoperative sedation.

2. At the time when the "blue line" becomes visible. The curve is not different from curve 1.

3. When a fine opening into the membranous endosteum has been made.

4. When the fenestra has acquired its final shape. Curves 3 and 4 are almost identical. As soon as the perilymphatic space is opened, the maximum primary gain is obtained, regardless of the size of the opening. The average gain for the frequencies up to and including 1024 was 16.3 decibels; above 1024 it was 6.3 decibels.

5. The flap placed over the fistula caused only a slight reduction of hearing.

For practical purposes it is sufficient to take curves 1 and 4.

Curves taken one to two months after the operation showed a secondary gain of 5 to 10 decibels for the various frequencies. The bone conduction did not vary significantly in the 18 cases examined.

**Aubry, M.** Surgery of Deafness, *Ann. d'oto-laryng.* **4:** 5, 1947.

The author reviews the history of the operation for deafness caused by otosclerosis and describes Sourdille's and Lempert's technics.

Aubry himself uses the endaural approach without excision of the triangular piece of skin. He performs atticotomy simply by enlarging the canal toward the roof without opening the antrum or the aditus. The incus is removed, and the flap is formed in such a way that it covers the entire internal attic wall and closes the opening to the antrum. In this way the bony reformation is reduced to a minimum, the mastoid process is excluded from the postoperative reaction, the postoperative labyrinthitis is prevented to a large extent and the time of operation is reduced.

The ideal fenestra should have the following properties: It should be large. This is achieved by making it in the ampulla of the lateral canal (what Lempert calls the dome of the vestibule). This position of the fistula does not cause prolonged dizziness except in a very small number of cases. The margins of the fenestra should be carefully thinned out and enchondralized, a procedure that also facilitates the adherence of the membranous labyrinth to the under surface of the flap which prevents interposition of bone. The endosteum should be completely removed with the help of magnifying glasses. Constant irrigation is useful. The flap should be made as thin as possible.

The author thinks that a successful Sourdille operation with preservation of a mobile incus should theoretically give a better result than a Lempert operation. With Sourdille's technic, however, a perfect result is more difficult to obtain.

In discussing the results of operation he feels that the statements of the authors who report success in about 90 per cent of the cases are too optimistic. He discusses the two methods of computing the results: (1) that of determining the average decibel gain and (2) that of determining whether the conversational level has been reached or not.

He discusses the various causes of failure. He then reports 2 cases in which the bone conduction was poor and the operation produced only a negligible improvement in hearing but was followed, in one of the cases, by disappearance of the noises; also, 2 cases in which the bone conduction was good. In another case a rupture of the drum membrane had occurred and the hammer had to be removed together with the anterior portion of the drum. The fenestra and the tympanic defect were covered with a Thiersch graft, which took, and the operation was successful.

In still another case, in which fenestration was done ten years ago, the hearing had not noticeably improved, but neither had it become worse, whereas there was a deterioration in the other ear, not operated on. He has observed 2 similar cases and feels that in these cases, in spite of secondary closure of the fistula, the otosclerotic process was arrested by the operation.

The author operates on all patients with good bone conduction whose loss of air conduction approaches or exceeds the minimum level of 30 decibels. The preoperative loss for bone conduction must not exceed 35 decibels. The operation is particularly indicated in cases of rapidly progressing impairment, no matter what the loss by air conduction, provided the bone conduction loss is not too excessive. The more affected ear should be operated on first; later, if the improvement has been maintained for at least eight months, the other side may be operated on.

The respective advantages and disadvantages of hearing aids and operations are discussed. The most important argument in favor of operation is the statement that the operation "seems to arrest or at least to retard the progress of the disease."

**Aubry, M.** The Surgical Treatment of Deafness: A Simplified Fenestration Technique, *Presse méd.* **55: 237, 1947.**

The technic consists in the following steps:

Only two endaural incisions are made, and the triangular piece of skin is not excised. The skin of the superior and posterosuperior circumference of the osseous external meatus is separated from the bone right up to the drum. Atticotomy is performed, and the malleus and the incus are thoroughly exposed. This is followed by removal of the incus and the head of the malleus. The fenestra is then made into the ampulla of the horizontal canal under continuous suction and irrigation. The flap is made from the detached skin of the meatus and reflected over the fistula and the medial wall of the attic. The flap covers the aditus and antrum and separates the mastoid process from the operative cavity.

The author's method results in a small operative cavity with considerably lessened danger of postoperative infection and discharge.

**von Békésy, G.** The Sound Pressure Difference Between the Round and the Oval Window and the Artificial Window of Labyrinthine Fenestration, *Acta oto-laryng.* **35** (no. 3): 301, 1947.

The author's summary is quoted:

Based on the principle of reciprocity a new method has been developed which permits the determination of quite small differences of sound pressure both as to magnitude and phase. By this method the differences of the sound pressure between the round and oval windows has been determined in human ear preparations lacking the middle ear apparatus. The pressure difference is so small that it can have no importance for the hearing of patients with missing middle ear apparatus. The established view that the round window is protected against the sound pressure in consequence of its place in a niche, is untenable.

However, in several preparations the differential sound pressure between the round window and an artificial opening at the ampulla of the horizontal semicircular canal is of the same order of magnitude as the sound pressure in the auditory canal. In this way a total hearing loss of only about 30 db arises as against the normal ear. Thus, in these cases a window at the semicircular canal would have been a fair substitute for a functioning middle ear apparatus.

By studying a model it is shown that the pneumatic cells of the mastoid process act as a resonance chamber in the mouth of which the artificial window is situated. This explains why a large sound pressure difference is found between the round and the artificial window, often in the whole hearing range above 500 c/s.

The possible clinical importance is mentioned of increasing this resonance chamber in labyrinthine fenestration operations.

**Bonham, W. L.** The Surgery of Deafness Due to Otosclerosis, *J. Oklahoma M. A.* **40**: 41, 1947.

This is a review of the problem for general practitioners.

**Brickley, D. W.** Otosclerosis and Blue Scleras, *Arch. Otolaryng.* **46**: 230 (Aug.) 1947.

This is a report of 2 cases illustrating the factor of dominant heredity. In one the transmission was through the male side, and in the other, through the female side. In the first case the deafness was initially manifested at the age of 19 years. It progressed rather rapidly, with the cochlear organ becoming involved in the relatively short time of three years. In the second case, the deafness was noted at the age of 29 years, and there was no nerve involvement after two years.

**Brunner, H., and Cutler, M. H.** Labyrinthine Symptoms Subsequent to Fenestration of the Labyrinth, *Arch. Otolaryng.* **45**: 613 (June) 1947.

The authors studied the symptoms and came to the following conclusions:

Twenty-four hours after fenestration of the labyrinth there is horizontal and rotatory nystagmus of the third degree to the side of the fenestration; the nystagmus disappears in three to four days. After surgical injury of the horizontal semicircular canal there is horizontal and rotatory nystagmus of the third degree to the other side, persisting for two to four weeks. This difference is caused by the infection which is always associated with surgical injuries. Such infection is usually absent in fenestration. When the patient looks straight ahead twenty-four hours after the operation there are frequently slow oscillatory movements of the eyes, synchronous with the pulse. Occasionally there is "nystagmus of the head."

If, after fenestration, the nystagmus is directed toward the side of the fenestration and decreases in a period of a few days, it is caused by the opening of the perilymphatic space. If, however, the nystagmus is directed toward the other side, or if it continues for more than one week, an infection of the fenestra is likely to have occurred.

The slow oscillatory movements of the eyes and the "nystagmus of the head" do not indicate an infection of the fenestra.

Pressure applied over the fenestra with cotton on an applicator yields a positive response more frequently than does the pneumatic pressure obtained with a Politzer bag.

There are cases in which probing of the fistula produces the fistula symptom, while compressing the air of the canal with the Politzer bag does not produce it.

After fenestration of the labyrinth the fistula test should be performed with the Politzer bag and not with the cotton applicator. The point at which the fistula is located in the horizontal semicircular canal does not influence the results of the fistula test.

Atypical responses to the fistula test do not necessarily mean inflammation of the perilymphatic space.

**Carruthers, D. G.** Surgical Technic of Operation of Labyrinthine Fenestration for Oto-Sclerotic Deafness, *Australian & New Zealand J. Surg.* **17**: 37, 1947.

The author finds local anesthesia highly satisfactory. He recommends a solution of epinephrine hydrochloride, 1:75,000. He describes the method of infiltration used by him. Under general anesthesia, there is at times a greater tendency to bleed. Lempert's endaural incision is adequate, but the regular mastoidectomy incision provides an almost equally good exposure, provided it is extended sufficiently forward at its upper extremity. With the posterior approach it is wise to make an incision in the skin of the external meatus to delineate the outer

end of the epidermal flap and to avoid tension on the part of the retractors, which may cause tearing of the lining in its more delicate inner part where it joins the tympanic membrane.

In the actual operation he follows Lempert's fenestra nov-ovalis technic with stopple. He thinks, however, that Shrapnell's membrane can never be made to cover the fistula, even when the latter is made far forward. The site of the fistula, in the fenestra nov-ovalis technic, is not in the position Lempert assumes it to be, on the surgical dome of the vestibule. It is over the anterior extremity of the external semicircular canal.

Postoperative vertigo never caused severe distress in any of the author's cases. There was a discharge from the wound for six to eight weeks, and sometimes an acute infection of the middle ear occurred at about the twelfth postoperative day, which persisted for three to eight weeks. The epithelization cannot be speeded up by the use of chemotherapy.

The author recommends that there be daily sterile dressings for at least four weeks.

**Cawthorne, T.** Otosclerosis, *Practitioner* **158:** 109, 1947.

This is a review of the pathology, symptomatology and therapeutics of otosclerosis for the general practitioner.

**Cawthorne, T.** Review of Surgery of Otosclerosis, *Proc. Roy. Soc. Med.* **40:** 320, 1947.

The author reviews the history of the surgical treatment of otosclerosis and then describes his own experiences.

He uses a Leitz dissecting microscope which gives 10 diameters of magnification and a working distance of 22 cm.

He thinks that any patient presenting uncomplicated otosclerosis is suitable for operation—that is, if the loss of hearing for the three crucial speech frequencies is not greater than 55 decibels. Lesions of the internal ear should be absent. Their presence is suggested by an alteration in the timbre of the patient's voice, intolerance of amplification, disappearance of paracusis and loss of acuity for bone conduction. However, the results obtained when bone conduction receviers are employed are not as accurate as those obtained with air conduction.

The author feels that with favorable conditions there is a 50 per cent chance of a substantial improvement of hearing that may be maintained for several years. In 5 per cent of the cases the hearing of the ear operated on may be much worse and may frequently disappear entirely.

**Croushore, J. E.** The Fenestration Operation for Otosclerosis, *Harper Hosp. Bull.* **5:** 128, 1947.

The author briefly reviews the problem.

**Day, K. M.** Medical and Surgical Care of the Patient Selected for Fenestration of the Labyrinth, *Arch. Otolaryng.* **46:** 534 (Oct.), 1947.

There are three primary causes of failure of the fenestration operation.

1. Faulty diagnosis and selection of cases. Cases may be included in which a perfectly performed operation will not restore practical hearing.

2. Fibrosis of the vestibule, resulting from hemorrhage, entrance of foreign material or damage of the vestibular contents.

3. Closure of the fenestra.

The faults which cause bony closure lie, in the author's opinion, mainly in the operator. A clean fenestra covered by a clean and healthy flap will not close in the absence of stimulative inflammatory reactions.

The patient should be in good physical condition and free from active nasal allergies. A patient whose psychologic stability is in doubt should be examined by a psychiatrist. If local anesthesia is employed, an explanation should be given to the patient concerning what he may expect to experience during and after the operation. If one of the barbiturates is used for intravenous injection, one should make sure that the patient is not allergic to barbiturates. Liberal intake of fluid is encouraged up to within two hours of operation.

During the preparation of the operative field, it is well to prevent mercurial or iodine solutions from entering the external meatus; occasionally the skin may prove sensitive to such solutions. Filling the external meatus with 70 per cent alcohol for ten minutes and then closing it with sterile cotton has proved to be adequate for antisepsis.

The packing should not be too tight; it should be nonirritative, nonadhesive and nonobstructive. Paraffin gauze is satisfactory in these respects. The packing can be removed on the fifth day. After that, for the next few weeks local treatment is usually limited to cleansing the external meatus and mopping out excessive secretion.

The patients should be encouraged to sit up on the day of operation and to get out of bed on the next day. Normal stimulation seems to hasten rather than retard the adjustment. These patients show less reduction of hearing for the high frequencies after three to four weeks than those who were confined to bed for several days after the operation.

The postoperative care of the cavity is often a real problem. Too many patients who are discharged before healing is completed acquire secondary infections which persist indefinitely. Both the operation itself and the after-care of the cavity are individualized problems which often test the surgeon's knowledge, judgment and ability.

**Editorial.** Surgery for Deafness, *Lancet* **252:** 181, 1947.

This is a general review of the problem.

**Editorial.** Surgical Treatment of Deafness, An. med., Barcelona **22:** 194, 1947.

**Ersner, M. S., and Saltzman, M.** Speech Hearing in Otosclerosis, *Arch. Otolaryng.* **46:** 753 (Dec.) 1947.

A characteristic response to tests for hearing of words was noted in patients with otosclerosis. There is greater loss for speech than for the frequencies most used in speech. There is a more marked loss for the words of the low frequency range. The air conduction audiograms of 3 different patients may show equal degrees of pure tone deafness, but the word tests may reveal differences. This difference aids in making a differential diagnosis between otosclerosis, nerve deafness and adhesive otitis media. The test words used are grouped into two lists. Common words of the lower frequency range constitute one; words of the higher frequency range, the other.

In otosclerosis the loss of hearing for words, particularly for words of the lower frequency range, is greater than the loss of hearing determined from the pure tone audiogram according to the Fowler-Sabin method of the American Medical Association.

In perceptive deafness the loss of hearing for words is less than the percentage loss of hearing for pure tones.

In adhesive deafness the word-hearing loss is still smaller.

In the differential diagnosis of the causes of deafness the patient's tolerance of, and benefit from, sound amplification are important.

In cases of otosclerosis microphone amplification offers an easy means of determining whether or not the patient is suitable for the fenestration operation.

**Farrior, J. B.** The Fenestration Operation for Deafness, *J. M. Alabama* **16:** 317, 1947.

This is a review of the problem for the general practitioner.

**Fishman, L. Z.** Lempert Fenestration: Preliminary Report on Fifteen Cases, *Bull. Pract. Ophth.* **16:** 11, 1946.

**Fishman, L. Z., and Fishman, V. P.** Tinnitus Aurium (Including Report of Results Following Lempert Fenestration and Tympanosympathectomy), *ibid.* **16:** 44, 1946.

Thirty-five fenestrations are tabulated for comparative study. Among these, many cases of so-called nerve deafness and of clinical otosclerosis are reported in which tinnitus was relieved completely or to a considerable extent by decompression of the labyrinth, irrespective of the degree of improvement obtained in the hearing; in some cases in which there was no improvement of hearing, tinnitus was, nevertheless, relieved.

Of 5 cases in which a Lempert sympathectomy was performed, the results were successful in 2.

**Flagg, P. J.** The Fenestration Operation: Major Hazard; The Anesthetic, editorial, *Am. J. Surg.* **72:** 497, 1946.

. . . the popularization of massive sedation as a substitute for general anesthesia in the fenestration operation endangers the life of the patient and prolongs the operative procedure. Bleeding in the field occurs from venous ooze and from arterial blood. Venous ooze is increased in respiratory obstruction and during spasm or straining from periosteal pain in which massive sedation is used. Sedation (barbiturates up to 9 gr. and morphine ½ gr.) requires prolonged and careful postoperative nursing to prevent asphyxial accidents. Safety is assured and venous oozing is eliminated by a properly conducted general anesthesia with ether carried on by the endotracheal inhalation technic without carbon dioxide absorption. Well selected, small doses of preoperative and postoperative medication provide comfort for the patient. The employment of this technic will prevent asphyxial deaths.

The author is against the use of intravenous pentothal sodium.® He mentions a patient who received 2.5 Gm. of pentothal sodium® over a period of one hour and forty minutes and was unconscious for three days. The temperature rose to 104 F. postoperatively. The patient was restless and respirations were depressed until recovery.

**Fowler, E. P.** Otosclerosis in Identical Twins: Five Case Histories, *Ann. Otol., Rhin. & Laryng.* **56:** 368, 1947.

The author discusses his studies of identical twins and in particular pertinent agreements and differences observed in five pairs of identical twins, all the members of which with the exception of one twin had otosclerosis. Detailed audiograms show the variations of hearing over several years. In every instance the twins were nursed or fed similarly and lived closely together; their finger prints and photographs were remarkably similar. Detailed personal, family and otologic histories and the results of laboratory examinations are given. The data are interesting, and much of the information is suggestive of cause and treatment. The following observations were discussed:

1. The mother's milk was deficient in every instance.

2. In the 8 females menstruation began earlier in the twin who is now the deafer in each pair.

3. Medication containing fluorine and a dietary intake of calcium and phosphorus were prescribed for at least one twin of each pair.

4. During several years little if any increase of deafness has been noted in these twins in spite of some childbirths and infections of the upper respiratory tract in several instances.

5. With the exception of one twin (twin A, fourth pair) the deafness was shared by both twins in each pair and by both ears of both twins in each pair. This is interpreted as indicating that either the hereditary or the environmental factors or both must have had similar etiologic effects in the two twins of every pair but one. In this pair only one twin had deafness, blue scleras and a noticeably nervous disposition. The other twin had normal hearing, white scleras and no noticeable nervous symptoms. This exceptional pair of twins will be followed with interest in the years to come.

**Fowler, E. P.** Otosclerosis, Progressive Deafness and Correlated Problems, *Hearing News* **15:** 5, 1947.

Excerpts are printed from the *Rhode Island Medical Journal* (**30:** 105, 1947).

**Fowler, E. P.** Otosclerosis, Progressive Deafness and Correlated Problems: What Has Research Discovered and What Does the Future Promise? *Rhode Island M. J.* **30:** 105, 1947.

This is a review of the subject presented at the meeting of the Eastern Section of the American Hearing Society in Providence, R. I., in 1946.

**Fumagallo, P. L.** The Surgery of Otosclerosis, *Arch. méx.* **5:** 378, 1947.

**Godsall, R. S.** Surgical Treatment of Deafness: The Fenestration Operation for Otosclerosis, *M. J. Australia* **1:** 62, 1947.

Godsall writes a letter to the editor of the *Medical Journal of Australia* condemning the "parish pump" outlook expressed in an article which he had read in the journal and which he believed to be at variance with current Australian medical and surgical thought. He states:

> With regard to the fenestration operation, there is no doubt that Lempert is a past master in this particular procedure, of which he has done several thousands. Holmgren of Sweden, who is looked on as the originator of this operation and has practiced it for three decades, remarked, after watching Lempert work, that he had learned more in that morning than in thirty years of his own work.

**Glynn, R. M.** The Lempert Operation, *M. J. Australia* **1:** 796, 1947.

The problem is reviewed.

**Gorelik, B.** The Surgery of Otosclerosis in U. S. A., *Ann. d'oto-laryng.* **64:** 659, 1947.

This is a general review and report of the transactions of the Annual Meeting of the American Medical Association held in Atlantic City, June 13 to 17, 1947.

**Guns, P.** The Problems of Deafness: Operation or Prosthesis, *Rev. méd. de Louvain* **5:** 73, 1947.

(This article is not available.)

**Hall, I. S.** Four Cases Illustrating Results in the Treatment of Otosclerosis by the Fenestration Operation, *J. Laryng. & Otol.* **61:** 644, 1946.

This is a report of cases.

**Hamberger, C.-A., and Nydén, H.** Cytochemical Studies on Experimental Bone Fistulae: A Contribution to Research in Otosclerosis, *Acta oto-laryng.* **35:** 479, 1947.

The authors' summary follows:

Bone formation in 200 experimental fistulae on the synciput of guinea-pigs has been studied by means of cytological and cytochemical methods. Anti-mitotics, colchicine and sodium cacodylate, have been used in an attempt to prevent the first phase of bone regeneration—the differentiation of the osteoblasts. These are characterized cytochemically in the normal course by the distinguishing features of cells with a considerable protein production. The occurrence of polynucleotides in high concentrations in the cytoplasm can be demonstrated and a well-developed nucleolar apparatus is found in the nucleus.

It appears highly probable that the osteoblasts actively contribute to the production of osteogenic tissue rich in proteins. Anti-mitotics delay and disorganize the development of osteoblasts by injuring the nuclear apparatus. The bone regeneration of fistulae is thereby delayed to approximately double the time, but is not prevented.

**Harris, H. E.** The Fenestration Operation in the Treatment of Deafness, *Ohio State M. J.* **43:** 741, 1947.

The problem is reviewed for practitioners.

**Harris, H. E., and Hale, D. E.** Induced Hypotension in the Control of Bleeding During the Fenestration Operation, *Tr. Am. Acad. Ophth.* **52:** 90, 1947.

In order to avoid troublesome bleeding, which occurs during the fenestration operation, in about 30 per cent of the cases, the following

procedure was used in 37 patients. Blood was withdrawn from the radial artery until the blood pressure fell to a level at which the operative bleeding was controlled. The blood was returned by the same route at the conclusion of the operation. The blood was withdrawn only at the time the effect was needed and was returned as soon as the need was past.

Blood was withdrawn until the systolic pressure had fallen to a level of 80 and was kept in flasks with a capacity of 500 cc. of blood and 50 cc. of a 4 per cent solution of sodium citrate. Usually about 1,800 cc. was withdrawn, but many patients did not receive back the last 500 cc. withdrawn. The resulting mild dehydration apparently reduced the local preoperative edema and lessened the vertigo, nausea and headache.

The procedure is not advocated for all patients, but only for those who show a tendency to bleed. If carried out under proper precautions it appears to be a valuable adjunct to fenestration surgery.

Discussion: W. M. Cole, Chicago, fears the method might produce serious cerebral anemia because the blood pressure might fall below 70 mg. of mercury. If the pressure stays below 70 for more than a few minutes, it is almost certain to be harmful.

H. House, Los Angeles, feels that troublesome bleeding has not been a major problem in fenestration surgery and that it can always be controlled by conservative methods patiently applied. He thinks that the suggested method is potentially dangerous.

**Hennebert, P. E.** The Audiogram in Otosclerosis, *Acta oto-rhino-laryng. belg.* **1:** 339, 1947.

The author found in audiograms of patients with otosclerosis and frequently in those of patients with lesions of the superior centers a "negative dip," i.e., an important conservation of hearing in a circumscript area, while at other frequencies a general loss of hearing was present. For patients with otosclerosis such a negative dip should be common experience. Its localization is mostly at 2048 or 4096. At this point the threshold may rise from 15 to 20 decibels above that for the neighboring frequencies.

**Henschel, C.** The Surgery of Deafness: Method of Fenestration, *Rev. méd. Liège* **2:** 575, 1947.

The problem is reviewed for the general practitioner.

**Hershey, S. G., and Jones, M. J.** Anesthesia for the Surgical Correction of Deafness, *Arch. Otolaryng.* **46:** 390 (Sept.) 1947.

The authors discuss the surgical and anesthetic problems involved in the fenestration operation, and a tentative anesthetic regimen is presented in relation to these problems.

It consists of the following steps:

1. Premedication with pentobarbital sodium, morphine and scopolamine hydrobromide.

2. Production of basal narcosis through rectal instillation of a tribromoethanol solution.

3. Induction of anesthesia by inhalation of nitrous oxide.

4. Insertion of both an oropharyngeal and a nasopharyngeal airway.

**Hicguet, G., and Van Eyck, M.** Thoughts and Observations About the Surgery of Deafness, *Ann. d'oto-laryng.* **64:** 634, 1947.

The authors make two incisions, similar to Lempert's first and second incision, and use a special retractor. In order to facilitate the thinning out of the skin of the meatus, a glass tube is introduced into the latter. An incomplete mastoidectomy is performed, and continuous irrigation is used while the fistula is being made. The operative cavity is filled with pieces of rubber sponge.

The authors noticed horizontal nystagmus to the side operated on when in the course of the operation the "blue line" became visible. The nystagmus did not change while the endosteum was exposed. However, as soon as the perilymphatic space was opened and perilymph escaped, the nystagmus changed its direction to the opposite side. It gradually subsided within two to three days; it is probably due to a disturbance of the equilibrium between endolymph and perilymph.

For the prevention of postoperative serous labyrinthitis, the authors recommend that 5 cc. of a 50 per cent magnesium sulfate solution or 10 cc. of a 10 per cent sodium chloride solution be injected intravenously every three hours for four days.

Sometimes considerable improvement in hearing was noted in the ear not operated on. Among the patients whose hearing was permanently improved, the fistula sign had completely or almost completely disappeared in all except 1.

**Hicguet, E. G.** The Surgery of Deafness, *Bruxelles med.* **27:** 71, 1947.

A case of unilateral otosclerosis in which the fenestration operation was performed is reported.

**Holmgren, G.** Otosclerosis Surgery, *Pract. oto-rhino-laryng.* **8:** 441, 1946.

The author discusses in detail the history of the operative treatment of otosclerosis. He stresses the difficulties of the clinical diagnosis of the disease and reports 42 cases. He used Lempert's fenestra nov-ovalis technic without stopple, with the endaural approach. The criteria for operation were less strict than those recommended by Lempert. Patients

with a hearing loss for bone conduction up to 50 to 55 decibels were included. In 1 patient with a bone conduction loss of 45 decibels for 1024 and 40 decibels for 2048 the result was excellent; not long enough time has elapsed since the operation to permit a final opinion. He nevertheless feels that the operative treatment gives excellent results. The question of indication is still unsettled and the technic still difficult. He reports his attempts at simplication, carried out on the cadaver.

He discusses the fact that in many patients the hearing on the side not operated on improves immediately after the operation. The improvement can be demonstrated by air and bone conduction. He does not know how long this improvement will last and is unable to explain it.

**Holmgren, G.** Surgical Treatment of Otosclerosis, *Časop. lék. česk.* **86:** 815, 1947.

After a historical survey of the evolution of the fenestration method, the author reports his own experiences and describes the details of various methods used in the United States. He believes that the operation and the postoperative care should be simplified and shortened by limiting the extent of the preparation to the lateral attic wall.

**House, H. P.** Indications for the Fenestration Operation, *Arch. Otolaryng.* **45:** 312 (March) 1947.

The author analyzes 111 cases in which patients were operated on by the Lempert fenestra nov-ovalis technic. Candidates for the operation may be classified as ideal, borderline and nonsuitable, depending on the amount of nerve function present in response to the speech frequencies. This is determined with tuning fork and audiometer. If the patient with clinical otosclerosis has a loss of serviceable hearing, the result of the Rinne test made with a 1024 fork is negative in direct proportion to the difference between air conduction and the degree of cochlear nerve function present.

Ideal Candidates: The von Mueller magnesium alloy 1024 tuning fork is heard ten seconds or longer by bone conduction than by air conduction. The nerve loss by audiometry is 10 decibels or less for the speech frequencies. Among 49 patients operated on, 39, or 79 per cent, have retained serviceable hearing for longer than six months. The fistula closed in 4.

Borderline Candidates. The 1024 fork is heard five to ten seconds longer by bone than by air conduction. The nerve loss by audiometry does not exceed 20 decibels for two speech frequencies, 512 and 1024, and is not more than 30 decibels down for the remaining most important frequency, 2048. Of 62 patients operated on, 34, or 55 per cent, have maintained serviceable hearing for more than six months. Closure of the fistula occurred in 8.

Candidates Not Suitable: The 1024 fork is heard longer by air conduction than by bone conduction. The nerve loss as shown by audiometry is more than 20 decibels for two speech frequencies, 512 and 1024, or more than 30 decibels for the remaining most important frequency, 2048.

Occasionally, the operation may be performed on a patient whose nerve function is shown by tuning fork and audiometer to be just below the lower limit for the borderline group. For a young patient who is encountering a rapid loss of nerve function "the operation may be justified as an attempt to prevent further loss of nerve function as well as to improve the hearing." Likewise a patient with otosclerosis whose nerve function is just below the lower limit for the borderline group and who is suffering from considerable tinnitus may at times be benefited by fenestration. Of 6 patients operated on, 2 obtained a practical hearing level. In one there was no audiometric improvement, but the tinnitus was eliminated in the surgically treated ear. This has allowed the patient to use his hearing aid with greater efficiency.

**Huizing, H. C.** Audiogram, Fenestration and Prosthesis, *Nederl. tijdschr. v. geneesk.* **91:** 12, 1947.

The audiogram is of great importance as indicating whether there is any necessity of fenestration in cases of otosclerosis. When bone conduction has decreased more than 25 decibels in the speech range, no operation should be carried out, and when air conduction has decreased more than 55 decibels (except in the incipient stage of otosclerosis) in deafness due to disease of the middle ear, an air conduction hearing aid with uniform amplification is indicated. In cases of inner ear deafness several types of audiograms were followed. When there is a uniform loss of hearing for all sounds, as well as when there is deafness of the abrupt type, a hearing aid with adjusted characteristics should be prescribed.

**Hutchinson, C. A.** Labyrinthine Fenestration: The Present Position, *J. Laryng. & Otol.* **61:** 567, 1946.

The author discusses the symptoms and the differential diagnosis of otosclerosis and reviews the historical development of the fenestration operation. He states that there are three slightly different technics in vogue: (1) the one stage transmeatal operation of Lempert and Shambaugh, (2) the two stage posterosuperior operation of Sourdille and (3) the one stage posterosuperior operation favored by Hall and him.

He feels that in the Lempert-Shambaugh operation the access and exposure are not free enough and the hemostasis less easy to secure. Sourdille now operates with the patient under local anesthesia. In

the first stage he performs a modified radical mastoidectomy and prepares the tympanomeatal flap with great care, aided by a magnifying loupe and paying particular attention to thinning the flap and trimming it to the required shape and size. He then removes the head of the malleus, but carefully conserves the incus, as he considers that doing so increases the mobility of the flap after final fenestration. The flap is then carefully placed in position and tamponed with paraffin gauze, and the incision is sutured.

Six months or so later he carries out the second stage. He reopens the incision, makes a semicircular incision in the shrunken, adherent flap posterosuperior to the prominence of the lateral semicircular canal, raises the flap so devised and rolls it forward so as fully to expose the prominence. Then, using an operating microscope and rasps of various sizes he fenestrates the semicircular canal close to the dome of the vestibule, reapplies the flap and tamponades it in place with paraffin gauze. The incision is then sutured. He does not employ irrigation or penicillin prophylaxis. Unlike certain American workers, he makes no claims to 80 per cent success but says that there is a 50 to 50 chance of success. The author thinks that he can obtain as good results with the one stage technic as with the two stage technic. If, however, adopting the two year criterion, one finds that one cannot equal Sourdille's results in a reasonable proportion of cases, it may be that one would be well advised to resort to the two stage technic.

Among the absolute contraindications of the operation he mentions otosclerotic changes which can be roentgenographically demonstrated in the bony wall of the external semicircular canal. Among the relative contraindications he mentions a low middle fossa and a forward lateral sinus, also any stage of pregnancy, because the disease is distinctly aggravated during pregnancy, and an age over 45 years.

He favors general anesthesia induced with gas-oxygen-trilene.

He uses the postauricular approach. At first a retroauricular incision is made, the periosteum elevated and the mastoid bone exposed. Then an incision is made through the membranous external meatus in the plane of the skull surface, from a point near the bottom of the posterior meatal wall, across this wall and the roof, to a point slightly beyond the junction of the roof and the anterior wall. From each end of this incision, further incisions are carried down at right angles to it to points just short of the line of attachment of the tympanic membrane.

The subsequent steps are essentially those of Lempert's fenestra nov-ovalis technic. The microscope is used for making the fistula.

The after-treatment follows the usual lines.

The causes of failure are: (1) retraction of the flap (rare); (2) keloid development (very rare); (3) secondary ulceration of the flap;

(4) injury of the membranous labyrinth; (5) acceleration of the otosclerotic process with degeneration of the organ of Corti (for this reason, operation during pregnancy is contraindicated); (6) faliure of a hearing center, atrophic as a result of disease, to recover its function; (7) osteosclerosis; (8) serous labyrinthitis.

There is a 50 to 50 chance of a permanent improvement of 25 to 35 decibels.

**Jackson, M.** Progressive Deafness and Its Cure, *South African M. J.* **21:** 674, 1947.

The author discusses the treatment of otosclerosis and of lymphoid tissue obstruction of the eustachian tube. For the latter condition he advocates the type of irradiation recommended by Dr. Crowe, of Baltimore. He then discusses the fenestration operation, which he uses in suitable cases.

**Jones, M. F.** Critical Survey of the Lempert Endaural Fenestration Operation, *Laryngoscope* **57:** 263, 1947.

The author divides the patients into four groups: (1) ideal patients (comparatively rare); (2) good risks (satisfactory and common); (3) poor risks (few have a chance to recover some hearing); (4) unsatisfactory (occasionally operated on—after the patient has been given a thorough explanation and a period of at least three months for consideration).

There are two essentials for obtaining the best results: proper selection of patients and proper training of the surgeon. There is a place for the fenestration operation, the hearing aid and the training program in the proper care of the patient with impaired hearing. The otologist should be the one best qualified to help patients in their selection. If the patient is a good surgical risk and the operation properly done, the operation is not dangerous. Persistent dizziness is rare; transient facial paralysis may occur. A discharging ear is the most annoying postoperative feature. The operation as a rule does not result in normal hearing but in "useful" hearing.

The greatest cause of failure of the fenestration operation is bony regrowth, which closes the artificial window. Wrong diagnosis is a close second. Surgical accidents are another cause. Infection is still another.

Standards for reporting have been proposed. The standard accepted by most otologists is the 30 decibel loss level for the three conversational frequencies. It is safe to assume that a hearing improvement maintained for two years will be permanent.

**Jones, M. F.** Symposium on Fenestration of Labyrinth: General Correlation, *Arch. Otolaryng.* **46:** 544 (Oct.) 1947.

Osteogenic closure of the fistula still remains a major cause of failure. The two methods employed by Lempert to prevent closure still hold some promise of success. These two methods may still be considered as in the experimental stage. Use of a lead burr appears to be a method of preventing closure, but lead may have other, deleterious effects. Lead is not an inert substance, and lead particles remain after the burr is used. It should not be recommended for general use at this time. In other hands than Lempert's the use of the stopple has not produced satisfactory results.

Bleeding is one of the factors contributing to bony regrowth. The author was unable to obtain a blood-free field consistently with any type of general anesthesia. However, this is achieved with the type of local anesthesia employed by Lempert and Branover. He considered it safe in the hands of these authors but does not share their feeling that it is safe in the hands of most operators.

The percentage of successful operations varies between 38 and 95 per cent for surgeons of equal ability. It seems inadvisable to state a definite percentage, but the author feels that there is a permanent improvement of hearing in more than 50 per cent.

The present standard of reporting is unsatisfactory, but it is the best so far proffered. It would be desirable to have some standard of reporting approved by the American Otological Society.

Whereas Day recommends a short postoperative confinement to bed, the author finds much less tendency toward vestibular disturbances and their consequences when the patient remains in bed and quiet for a longer time.

Training methods for the development of understanding and capable fenestration surgeons should be subject to the approval of authoritative bodies.

As a protection of the public, certification of those qualified in fenestration surgery should be implemented by the American Board of Ootolaryngology at once.

The author takes exception to the statement of Maxwell: "The performance of the fenestration as a surgical experiment is a violation of the ethical conception of the profession." He hopes that Maxwell will consider the implications of such a statement when applied to all innovations in medicine and especially when applied to fenestration surgery.

**Kelemen, G.** Fenestration of the Labyrinth: A Bibliography, *Laryngoscope* **58:** 74, 1948.

**Kopetzky, S. J.** Evaluation of the Fenestration Operation in Otosclerosis, *Nebraska M. J.* **32**: 53, 1947.

Patients who are to undergo the fenestration operation should be told the whole truth regarding the uncertainty of any prediction of the outcome. They should not be misled by having statistical figures quoted to them, for there is no known means by which the surgeon can truthfully tell whether in a given case the result will be a success or a failure.

On the basis of the findings of Grunert (1896, 1897) the author believes that in two thirds of the cases the round window and the acoustic nerve are involved in addition to the stapes and the oval window. In these cases the operation cannot improve the hearing.

Too many patients with a rationalized diagnosis of "clinical otosclerosis" are operated on before the diagnosis is definitely established. More stringent criteria should be used and in questionable cases medical therapy tried.

As a procedure the fenestration operation has a place in otologic surgery. However, the operation must still be classified as in the evolutionary stage. The question whether it is a valuable means of improving impaired hearing is at this time much unsettled.

A postoperative period longer than two years will become increasingly necessary before one may finally determine whether or not further evolution of the otosclerotic lesion will not bring with it further deterioration of hearing. In view of the shock entailed by a failure to attain expected results, a careful preoperative psychiatric examination of the patient should be undertaken, to eliminate postoperative psychiatric breakdown.

**Kranz, F. W.** A Report on the Fenestration Operation, Elmsford, N. J. Sonotone Corporation, 1946.

The author reviews for laymen the present status of the fenestration operation.

The benefits which are obtained from this window operation in some cases are not to be minimized and it seems probable that improvements in technique will increase somewhat the proportion of cases which will be benefitted. However, it does seem desirable to recognize as clearly as possible where this operation fits into the general problem of the treatment of the hard of hearing, and to recognize that only a minor group of hard of hearing people are suitable candidates for the operation, and that the operation is successful in only a percentage of the cases which are operated on. This operation has its legitimate place in the treatment of the hard of hearing but it appears that it does not appreciably change the status of the well fitted modern hearing instruments as a means for the restoration of hearing.

**Lempert, J.** Lempert Fenestra Nov-Ovalis Operation for the Restoration of Serviceable Unaided Hearing in Patients with Clinical Otosclerosis: Its Present Evolutionary Status, *Arch. Otolaryng.* **46:** 478 (Oct.) 1947.

Despite progress in the fenestration technic, two questions remain unanswered.

1. Will the patient's acuity of hearing be improved to the level necessary to insure practical, serviceable unaided hearing for both social and economic contacts?

2. If the hearing is improved to the "serviceable" level, will it remain at that high level permanently?

Although with the tests available at present one can in the majority of cases determine preoperatively the likelihood of restoring serviceable hearing as a result of fenestration, these tests, being subjective, are not always infallible.

The author feels that otologists still have no better method of determining the degree of function of the cochlear nerve in conduction deafness than the careful and intelligent use of the 512, 1024 and 2048 steel tuning forks; he suggests the following test: The patient must face the examiner with chin up and eyes widely open. Synchronously with the cessation of the hearing of the fork by bone conduction the eyes deviate involuntarily to the side and in the direction of the fork. This deviation of the eyes is due to the patient's search for the sound which he has just lost.

Although, owing to the advances made in the fenestration technic in the last ten years, a large percentage of the newly created fenestras have remained permanently open, otologists have no way of knowing in advance which ones will remain patent.

The author reviews all his endeavors to improve fenestration technic from 1938 to 1947.

Attempts to prevent locally osteogenesis in the newly created fenestra were made on the following two surgical principles: 1. Physical impedance must be offered to the osteogenesis that starts and spreads from the normal freshly cut periosteal, enchondral and endosteal layers of the fenestral rim, and thus force the same to heal without osteogenetic repair. 2. The histologic structure responsible for osteogenesis within the freshly cut margins of the three layers of the bony fenestral rim must be devitalized and inactivated without being destroyed.

With regard to the first principle he states that pressing the tympanomeatal flap tightly into the fistula ("soft tissue impedance") does not necessarily prevent the closure of the fistula. The adhesions that may develop between the membranous labyrinth and the tympanomeatal flap are not a means of preventing osteogenetic closure of the newly cre-

ated fenestra as assumed by Lindsay, but are a result encountered occasionally because, for some unknown reason, osteogenesis did not take place.

An inert metal frame obturator fitted into the bony rim of the fistula could prevent osteogenesis, but its use will remain impracticable until a method of creating a fenestra of standard size and shape is developed, so that a prefabricated frame can be used.

A properly fitted cartilage stopple will prevent osteogenesis, but fibrous adhesions between the stopple and the margin of the fenestra might render the stopple immobile.

The use of perforated, tightly fitting stopples is inadvisable, because the opening in the center cannot be made large enough to permit sufficient mobilization of the perilymph and the endolymph by air-borne sound. The only hope of reaching the desired objective with the stopple lies in a two stage technic—in forcing healing without osteogenesis by tightly inserting the stopple, then removing the stopple and covering the fistula with a tympanomeatal flap.

In the attempt to prevent osteogenesis by the second principle controlled experiments were made in monkeys, in which the walls of the fenestras were burnished with various substances, such as steel, gold, silver, silver amalgam and pure lead. The only fistulas which stayed open were those in which the freshly cut walls were burnished with lead.

The author now uses the lead technic continually. He hopes that time will prove that all the surgical problems heretofore encountered can now be successfully solved. Lead burnishing is evidently not injurious to the endolymphatic labyrinth or to the organ of Corti. In 3 patients operated on with this technic more than five years ago, the fistula has remained open and the original improvement of hearing has been maintained. If microphone amplification greatly improves the hearing of speech, the chances are that a fenestra nov-ovalis will do likewise.

**Lempert, J.; Meltzer, P. E.; Schall, L. A., and Wolff, D.** Osteogenesis Following Fenestration of the Vestibular Labyrinth of the Rhesus Monkey: A Controlled Experimental Study, *Arch. Otolaryng.* **46:** 512 (Oct.) 1947.

Osteogenetic repair of fenestras newly created in the vestibules of the labyrinths of the rhesus monkey and its prevention were studied. Forty-one monkeys (82 ears) were operated on.

Bone regeneration is initiated by fibrosis which fills up the middle ear, crossing over the fenestra at first and later filling in the fenestra. The periosteal bone is the first to regenerate in the untreated ear.

After this, more or less simultaneously and independently, endosteal bone, bone deposited by accretion around fragments of mature bone, and islands of newly deposited bone appear.

There is no evidence that enchondral bone is immue to regeneration. Enchondral bone was observed to regenerate in some of the experimental and control ears and not in others. The size of the fenestra seems to have no bearing on the ultimate regeneration of bone.

Burnishing the freshly cut rim of the fenestra with 24 carat gold, silver, silver amalgam or stainless steel, with 2 per cent aqueous solution of gentian violet, or with electrocoagulating current did not prevent bone regeneration. Burnishing with pure lead, in 2 monkeys, prevented bone regeneration (autopsies made after six months and twenty-eight days).

Regeneration did not occur when a cartilage stopple was fitted firmly against the cut edge of the capsule.

Fibrin foam or film does not prevent regeneration. The skin flap laid over the window does not prevent endosteal bone from forming beneath it or even periosteal bone from creeping under it and crossing the window.

**Lempert, J.; Wever, E. G., and Lawrence, M.** The Cochleogram and Its Clinical Application: A Preliminary Report, *Arch. Otolaryng.* **45:** 61 (Jan.) 1947.

In order to determine whether a case of otosclerosis is suitable for the fenestration operation, one must have an objective test by which to recognize preoperatively the existing reservoir of cochlear function in a deafened ear. The authors report their preliminary experiments which have the goal of developing a standardized cochleogram so that any deviation from the normal can eventually be studied and recognized.

Electrical potentials arising in the cochlea in response to sounds have been observed in a great variety of experimental animals and probably arise in the hair cells of the organ of Corti. In man a cochlear response of similar character has been observed.

The authors studied the responses in 11 cases in the course of operating for otosclerosis, tinnitus or Ménière's disease. With the electrode inserted in the round window niche and probably in contact with the membrane, clearly positive responses were observed coming from 4 ears and faint responses from 2 ears. The remaining ears yielded negative results, probably because of failure of the electrode to make contact with the round window membrane. Other placements occasionally tried, at the edge of the niche, on the promontory and at the newly opened fenestra in the region of the ampulla of the horizontal canal, were unsatisfactory.

**Lindsay, J. R.** Healing of Experimental Labyrinthine Fistulas: Further Observations, *Arch. Otolaryng.* **46:** 584 (Nov.) 1947.

The experiments were carried out in monkeys.

The interpretation based on the previous experiments, that success in maintaining a patent fenestra in a semicircular canal is dependent on the degree to which the membranous canal is preserved in its normal position at the outer periphery of the bony canal where it is free to come into direct contact with whatever covering may be used over the fistula, appears to be supported.

A factor contributing to the successful application of a covering flap consists in locating the fistula on the convex surface of the mound formed by the wall of the horizontal canal slightly distal to the ampulla.

In monkeys several types of flap have been utilized to prevent bony closure, with varying degrees of success. (*a*) A conjunctival graft with epithelium outward was successfully employed. (*b*) Thiersch grafts were used successfully in several instances. (*c*) Grafts of the thin skin and periosteum of the wall of the external auditory meatus proved preferable to Thiersch grafts. (*d*) The tympanomeatal pedicle flap used in the Lempert operation was the most successful covering tried in the monkey.

Absence of bony closure of a fistula has been obtained in 2 patients without the application of any covering. In each patient the fistula was made, after a complete simple mastoidectomy, without interfering with the drum membrane, the middle ear or the ossicular chain.

In the first patient, at reoperation after about fifteen months, the fistula was found covered by mucoperiosteum. The ability to limit osteogenesis is not a characteristic only of the epidermis. The same result has been obtained with conjunctiva and with mucoperiosteum under suitable conditions.

The degree to which an epidermal flap or graft is effective in preventing osteogenesis between it and the bony surface underneath appears to depend on the maintenance of close apposition.

In the 2 patients the same forces which accounted for the repneumatization of the mastoidectomy cavity seem to have contributed to the prevention of osteogenetic closure while the mucoperiosteum was growing across the fistula.

**Lindsay, J. R.** The Fenestration Operation: Observations on the Evaluation of Hearing Tests, *Laryngoscope* **57**: 367, 1947.

The author's summary follows.

Complete closure of the fenestra after the Lempert nov-ovalis operation has become an infrequent complication.

A decrease in the hearing improvement for low frequencies in the third to the sixth month is common and is evident in many cases which may still be classed as successful results.

Hearing for the 2,048 and 4,096 frequencies is most consistently maintained after operation. This region is most important for speech perception.

A comparison between preoperative bone conduction thresholds, and the maximum postoperative hearing gain has shown a close correlation.

The possibility for improvement in speech perception appears to be most accurately indicated by the preoperative bone conduction threshold values at 2,048 and 1,024 cycles.

**Marvil, J. E.** Problem of Deafness, *Delaware State M. J.* **19:** 189, 1947.

Marvil discusses the various types of deafness and their treatment for general practitioners.

**Maxwell, J. H.** Training of Surgeon and Selection of Patient for the Fenestration Operation, *Arch. Otolaryng.* **46:** 539 (Oct.) 1947.

The prerequisite training of the surgeon should include first of all a wide background of diagnostic and surgical experience in the general field of otolaryngology and a thorough knowledge of the entire problem in all its phases. He should operate on cadavers under supervision, and he should observe experienced surgeons perform the operation. If it can be made practicable, it would be well for the national societies to elect a rotating board of otologists to determine the qualifications and to issue certificates of proficiency in this field.

There is considerable latitude in the selection of patients suitable for the fenestration operation.

In cases in which the presence of clinical otosclerosis can be assumed, the age of the patient and the rate of progress of the impairment should be considered. The operation is indicated in young patients with fast progressing impairment. Three or four audiograms should be taken, and the hearing threshold checked by tuning fork tests. The chief value of the tuning fork tests is to check the audiogram, which on many occasions is found to be inaccurate in spite of frequent calibration of the audiometer. Testing of speech reception is most important. The present tendency to conclude that a patient is handicapped or that the fenestration has not been successful if slightly more than a 30 decibel loss has been recorded on the audiogram for just one or even two of the tones seems absurd.

If a patient has been rehabilitated by fenestration so that he can carry on normal group conversation, the operation must be regarded as successful even though in some instances there may be a loss of 70 decibels for one or possibly two of the frequencies.

No patient is suitable for fenestration unless it can be shown by accepted tests that there is sufficient cochlear function to permit the hearing to be restored to a serviceable level through the successful by-passing of the obstructive element. The performing of the fenestration operation as a surgical experiment is a violation of the ethical concepts of the medical profession.

**Mayer, O.** On the Cause of New Formation of Bone in the Basal Turn of the Scala Tympani in Otosclerosis, *Monatschr. f. Ohrenh.* **81:** 113, 1947.

The bone tissue which in patients with excessive otosclerotic areas is sometimes formed in the basal turn of the scala tympani extends from the inner surface of the promontory across the lumen of the scala to the cochlear capsule. The bone shows a very primitive structure. The author thinks that the newly formed bone represents a functional structure which tends to buttress the extensively involved capsule and to prevent its threatening collapse. The histologic changes are similar to those in bone regeneration (callus formation).

**Meltzer, P. E.** Revision of the Fenestration Operation, *Arch. Otolaryng.* **46:** 528 (Oct.) 1947.

Accidents excluded, osteogenesis, fibrosis and labyrinthitis, in this order of importance, are the causes of postoperative failure.

The new bone is easily distinguished from the surrounding bone during the first year or two; later it may become indistinguishable. In some cases marked tissue repair will lead to bony closure even if the operative technic has been faultless.

If the fistula has been well made, 4 to 4.5 mm. long, 1.5 mm. wide, with no endosteal shreds and with bone debris and chips thoroughly removed from the cavity, it should not be revised under the following conditions: if there was no improvement of hearing after the operation or if the hearing did not reach the practical level at any time; if the hearing did not reach the practical level in the speech frequencies; if the improvement of hearing was lost rapidly within three to six weeks. The last event usually means fibrosis.

A revision should be made if the original fistula was too small. It should be made if the improvement of hearing remains for six to eight weeks and is then rapidly lost, and one has a feeling that a fragment of bone might have made its way into the window or that a spicule of bone was attached to the canal wall membrane. In these instances one might revise sooner than usual, provided the cavity is clean and well epidermized.

The best time for revision of the fistula is usually from six to twelve months after it has become evident clinically that the fenestra has closed.

If during reoperation it seems difficult to expose the perilymphatic space and there is fear that further instrumentation will result in damage of the membranous labyrinth, one should stop the procedure and replace the flap over the fenestra. On elevation of the flap one may find fibrous tissue extending into the window, or the perilymphatic space may be

filled with organized material. Attempted removal will generally evulse the membranous labyrinth.

The number of cases in which hearing is improved by revision is small, about 20 to 25 per cent in well selected cases. In 15 to 20 per cent it may be improved but not to the practical level.

The danger of the hearing being made worse by revision is much greater than at the time of the original operation. It is necessary to exercise good judgment as to when not to tinker unnecessarily at the time of revision.

**Moorhead, R. L.** Fenestration for Otosclerosis: Report of One Hundred and Twenty-Three Cases, *Arch. Otolaryng.* **45:** 49 (Jan.) 1947.

The author reviews the results obtained in 123 consecutive cases seven months to four years after operation.

There are three groups of patients in whom the operation is performed: (1) those with good hearing for bone-conducted sounds; (2) those with marked nerve degeneration which has not, however, progressed to a sufficient degree to warrant the assumption that no improvement of hearing will be obtined; (3) patients with an unfavorable degree of nerve degeneration "who wish to take the chance, or on whom the otologist wishes to operate for one reason or another." Operation is perfectly justified in this last class for, if it is properly performed, even if no improvement of hearing is obtained, these patients are in no way worse off than before the operation.

There were no deaths in the whole series. Transient facial paralysis occurred in 2 patients; postoperative perichondritis, in 1. There were none in whom vertigo persisted. In about 10 per cent of the patients the cavity continued to discharge.

Fifty-seven of the 123 patients, or 47 per cent, recovered serviceable hearing, with threshold at the 30 decibel level or better for all the three conversational frequencies. In 19 patients, or 15 per cent, the 30 decibel level was reached or exceeded for two of the three conversational frequencies. These two groups should be classified as enjoying successful results. In the third group are 11 patients, 19 per cent, in whom the 30 decibel level was reached in only one of the frequencies. In 36 patients, 29 per cent, there was no improvement of hearing at all, but only 5 per cent had their hearing diminished below the preoperative level.

In 24 patients the cartilaginous stopple was used. The final results in these were not markedly different from those in patients operated on without it.

**Nodine, E. R.** Evaluation of the Fenestration Operation for Deafness, *J. M. A. Alabama* **16:** 236, 1947.

This is a short review for general practitioners.

**Ombrédanne, M.** Surgery of Deafness: Fenestration in Cases of Congenital Atresia of the External Canal, *Oto-rhino-laryng. internat. Lyons* **31:** 229, 1947.

The author reports 2 cases in which fenestration of the ampullated end of the horizontal canal and covering of the fenestra with a flap from the retroauricular region produced a remarkable improvement of hearing.

**Passe, E. R. G.** Bilateral Clinical Otosclerosis Treated by the Fenestration Operation Using the Cartilage Stopple and the Endaural Approach, *Proc. Roy. Soc. Med.* **40:** 319, 1947.

The author successfully applied the fenestra nov-ovalis technic with stopple. Jacobson's nerve over the promontory was destroyed by diathermy.

**Passe, E. R. G.** The Fenestration Operation for Otosclerosis, *Post-Grad. M. J.* **23:** 507, 1947.

For this review the author discusses the following topics:

1. Classification or Grouping of Patients Who Have Otosclerosis.

Group 1. Those in whom clinical and audiometric examination for hearing of both pure tones and speech established beyond doubt that the reserve of cochlear function is adequate. In this group 80 to 90 per cent find their hearing restored to the practical conversational level.

Group 2. Borderline patients with cochlear damage apparently so extensive that it will be necessary for the maximum improvement to be obtained if the practical hearing level is to be reached. In this group success can be anticipated in 20 to 40 per cent.

Group 3. In these patients the cochlear nerve has deteriorated so far that the chances of improving their hearing by operation are practically nil. Occasionally, however, in such patients the hearing for the low frequencies of 256 and 512 has been restored to such an extent as to enable conversation to be heard clearly.

Bone conduction, while not a decisive criterion of the state of the acoustic nerve, is frequently a great help; the former guiding level of 30 decibels for the frequencies 1024 and 2048 may now be lowered to 40 decibels.

Paracusis willisiana, if present, is a most important guide to the possibility of operation. If absent, it definitely excludes the patient from the benefits of the operation.

The period during which deafness has been increasing is not definitely significant. The greatest acuity may be expected after operation in young persons, but successful results may also be obtained in the elderly.

Improvement of air conduction is frequently observed for a short time after a successful operation in the ear not operated on. In the ear operated on, the bone conduction is occasionally improved, but frequently it is worse.

2. Evolution and Execution of an Efficient Fenestration Technic.

The author uses the microscope and constant irrigation. He removes more of the periosteal layer around the canal and the domed vestibule than other operators, leaving only a thin eggshell layer of endosteal bone extending from the dome of the vestibule, anteriorly, to the downward bend of the lateral semicircular canal, posteriorly; on top of this area a fenestra of almost 1 cm. is then made. No cartilage stopple is used. The flap is formed of the anterior meatal wall. It is always possible to cover the dome of the vestibule and the ampulla of the lateral canal with this thin skin, but it is not always possible to cover the prolongation of the fenestra around the bend of the lateral canal with it.

Damage to the membranous labyrinth does not prevent practical restoration of hearing. In cases of Ménière's disease, treating the patient by extraction of the lateral and superior membranous canals, after sealing off the articular ends by diathermy, did not result in further deterioration of the patient's already somewhat lessened hearing.

3. Institution of a Meticulous and Rigidly Aseptic After-Treatment.

In order to avoid postoperative stenosis a single S-shaped endaural incision is used, which produces a flap of skin hinged posterosuperiorly, which at the end of the operation is folded back into the meatus and held up against the lower border of the temporalis muscle by means of a suture passed through the flap and the skin of the postauricular groove. An absorbable cellulose packing is used.

4. Notation of Follow-up Records Based on Standard Tests.

5. Tinnitus in Relation to Otosclerosis and the Fenestration Operation.

In approximately 25 per cent of the patients tinnitus is either abolished or greatly reduced. In 60 to 70 per cent it remains unaltered in intensity, but may be altered in tone. In a small percentage it may become worse for a short time. Destruction of the tympanic plexus has no effect on tinnitus. It is of use only in cases in which tinnitus is possibly due to inflammatory irritation of this plexus. Tinnitus in the patient with otosclerosis is, in the author's opinion, possibly due to spasm of branches of the internal auditory artery as well as of branches of the tympanic artery.

He has found that severance of the preganglionic fibers of $T_1$ and $T_2$ produces instantaneous and complete cessation of the pulsating type of tinnitus. One patient with early otosclerosis on whom stellectomy was performed showed a marked gain in hearing with complete cessation of the tinnitus, although the hearing still continues to deteriorate and the tinnitus to persist on the side not operated on. It is still questionable whether it is desirable to perform sympathectomy on both sides or not. Up to now most of the work on the sympathetic supply of the vessels of the ear has been done on the superior or the inferior cervical ganglion, but this neglects the branches going to the vertebral artery, which are most important.

6. Results of the Fenestration Operation as Compared with Those Obtained by Hearing Aid.

The author stresses the superiority of the operation. Whether or not in successful cases the operation either arrests or prevents the usual nerve degeneration of otosclerosis cannot yet be answered with certainty. A careful examination of the ear not operated on has been made in a large percentage of cases in which the hearing of the fenestrated ear was improved. It has shown that slight improvement does occur, up to 10 or 15 decibels, but that this improvement is purely temporary. In none of the author's cases has it persisted for more than six months.

In the author's opinion, the critical period during which an "enchondralized fistula" may close is six months.

**Passe, E. R. G.** Fenestration Operation for Otosclerosis: Interim Report on One Hundred and Thirty-Six Cases, *Lancet* **1:** 171-174, 1947.

The author discusses briefly the historical development of the operation and the symptoms and the diagnosis of the disease. He divides the cases into three groups (see foregoing review of Passe, E. R. G. *Post-Grad. M. J.* **23:** 507, 1947).

He operates now only in cases in group I and uses Lempert's fenestra nov-ovalis technic with and without a stopple. He uses continuous irrigation according to Shambaugh. The operation is done under pentothal sodium® anesthesia after heavy premedication. Vitamin K and calcium lactate are given preoperatively. The patients get up usually on the third or the fourth day and leave the hospital on the tenth to twelfth postoperative day. Age is no contraindication, provided that the cochlear nerve still retains its function.

**Passe, E. R. G.** Technic of Fenestration Operation, *Proc. Roy. Soc. Med.* **40:** 319 (no. 6), 1947.

A colored film is used to demonstrate the technic.

The author states that he has now given up the insertion of a cartilaginous stopple, because it does not permit as great an increase in hearing as a fistula without stopple; it does not materially reduce postoperative serous labyrinthitis; it does not necessarily prevent bony or fibrous closure of the fistula. There is the further difficulty of insertion, as well as the added risk that the membranous labyrinth might be injured during the insertion and the associated manipulations.

**Popper, O.** Fenestration of the Labyrinth: II. Transtympanic Fenestration, *J. Laryng. & Otol.* **61:** 441, 1946.

In this paper the author's purpose is to fill in and accentuate important details of his previous paper of the same year.

He uses a binocular head gear giving magnification of about 1½ diameters and a working distance of 6½ inches (16.5 cm.). A detailed description of the instrument is given.

General anesthesia is used (induced with open ether, oxygen and pentothal sodium,® followed by open ether and oxygen or by intratracheal ether and oxygen; intratracheal ether and oxygen alone; continuous pentothal sodium®).

The patient's face is turned toward the surgeon, and this relative position is maintained during the operation.

He describes the operation in eight stages and illustrates each stage with colored pictures.

The author gives a hydrodynamic hypothesis for the improvement of hearing that occurs with fenestration in cases of otosclerosis. He assumes that sound is transmitted to the inner ear through the round window. The auditory ossicles and muscles are not organs of sound transmission but of accommodation and protection. A mobile normal stapes acts as an escape valve to allow for displacements or vibrations of the perilymph, excited by sound impinging on the round window. The normal stapes is able by muscular action to control and adjust the amplitude of the excursions of the perilymph.

Possibly another function of the stapes is to adjust the tension of the round window membrane by hydraulic action. A specific tension will filter out or dampen unwanted frequencies and thus accentuate, or focus on, a particular sound spectrum. This function is, in the author's opinion, the first to disappear in otosclerosis.

In fixation of the stapes the escape valve action is absent. The wave is therefore suppressed, dammed back, dampened and distorted and can, therefore, stimulate only the organ of Corti, but feebly. If the entire capsule plus the perilymph is set into vibration, hearing is good—as in bone conduction in otosclerosis.

Fenestration of the labyrinth creates a new escape valve.

The tympanic membrane has three main functions: 1. It is a most perfect receptor for sound. 2. It assists by variations of tension to "focus" for sound. 3. It protects the organ of Corti by an immediate tympanostapedial reflex and by relaxation, curtailing and dampening sound vibrations.

**Popper, O.** Fenestration for Otosclerosis, *Presse méd.* **54:** 648, 1946.

The author gives a short description of the method which is described in detail in the *Journal of Laryngology and Otology* (61:441, 1946).

**Rosen, S.** Learning the Lempert Fenestration Operation, *Arch. Otolaryng.* **45:** 335 (March) 1947.

The author stresses the technical difficulty of the operation and the necessity of practicing on the cadaver and watching a great number of operations performed on the living, by competent surgeons.

**Rosenberger, H. C.** The Fenestration Operation for Otosclerosis: A Discussion and Report of Results, *Ohio State M. J.* **43:** 1042, 1947.

This is a discussion of the problem for general practitioners.

Among the 32 patients operated on by the author, 12 had their hearing for the frequencies 512, 1024 and 2048 brought up to or above the 30 decibel level, 3 to the 35 decibel level and 4 to the 40 decibel level. These patients are just as satified with the results as those whose improvement reached the 30 decibel level. Nineteen patients (59 per cent) had an excellent or a good result; 8 or (25 per cent) have a fair result, which they appreciate and to which they are able to make adjustments without resorting to a hearing aid. Poor results ensued in 5 (15 per cent).

One patient experienced transient facial paralysis, and 2 patients, closure of the fenestra. One patient maintained an excellent improvement for eight months; then there was a rapid return to the preoperative level, coincident with pregnancy. The fistula symptom remained active.

**Rosenberger, H. C., and Bukovina, E. R. N.** Fenestration: The Success of This Delicate Operation Depends on Expert Nursing Care as Well as Surgical Skill, *Am. J. Nursing* **47:** 730, 1947.

The authors discuss the principle of the fenestration operation and certain important factors in the nursing care. Every patient is a potential psychiatric problem. Having been afflicted with deafness—sometimes over a prolonged period—the patients are prone to be emotionally unstable. They are likely to seize on the fenestration operation with

the immoderate hopes and enthusiasm of a zealot. A thoughtless word uttered by the nurse may profoundly influence such a patient.

Postoperative care is indubitably important. The patient should lie on his back or on the ear operated on; he should be watched closely for facial paralysis.

**Salem, W.** The Fenestration Operation of Lempert for the Treatment of Deafness: Results in Seven Cases, *Rev. brasil. de oto-rino-laring.* **15:** 101, 1947.

The author reviews the literature of the last few years regarding the fenestration operation. He studies the physiologic basis of the operation and its results and reports observations concerning 7 patients whom he operated on.

The complications of the operation are reduced to the minimum, there being practically no serious postoperative complications. It is possible to obtain excellent results in 70 per cent of the cases, and with further improvement of the technic, the results might become even better.

**Salem, W.** Lempert's Fenestration Operation for the Treatment of Deafness: Results in Seven Cases, *Hospital, Rio de Janeiro* **32:** 565, 1947.

**Salomon, J.** Surgery of Deafness, *Semaine d. hôp. Paris* **23:** 182, 1947.

This is a general review.

**Shambaugh, G. E.** The Fenestration Operation: An Evaluation of Its Present Status, *Surg., Gynec. & Obst.* **84:** 828, 1947.

The operation is useful in two types of cases: (1) the ideal case in which there are ankylosis of the stapes and normal cochlear function and the patient has an 80 per cent chance of a permanent improvement of hearing and (2) the suitable case in which the hearing by bone conduction is normal except for one of the speech frequencies and the loss for this frequency is 30 decibels or more. In this type of case the patient has a 50 per cent chance.

There are two other types of cases. There is, first, the experimental case in which tests with two or more of the speech frequencies show a 30 decibel or greater loss for bone conduction, but the Rinne test with the 1024 fork is negative. In cases of this type there is a 1 in 10 chance of sufficient improvement to give practical hearing without an aid. Then there is the unsuitable case in which impairment is due either to

incomplete fixation of the stapes or to profound nerve degeneration. In this type of case the operation is contraindicated. The worse ear should always be operated on.

In the selection of patients the following four tuning fork tests are particularly helpful:

1. If the patient cannot hear the 64 fork at maximum intensity close to the ear, the stapes may be regarded as completely ankylosed. If the fork is audible by air at moderate intensity, the fixation of the stapes is incomplete and the operation contraindicated because there is too little to be gained.

2. If the Rinne test with the 1024 fork is negative, the opposite ear being masked, the hearing should be improved by the operation even though the case is suitable but not ideal or an experimental case.

3. If the Rinne test with the 512 fork, the opposite ear being masked, shows that air conduction is better than bone conduction, the fixation of the stapes is only slight and the operation is contraindicated.

4. If the 2048 fork is not heard by bone conduction, the opposite ear being masked, the prognosis is poor.

The judgment as to which technic is the best must await the publication of adequate detailed statistical data. The author uses the fenestra nov-ovalis technic with "enchondralization," irrigation and microscope.

Two years after the operation, among 415 patients operated on, there was fully maintained improvement in 363 (81.5 per cent) and a further loss in 7 (1.7 per cent).

Among those whose hearing was improved, the 30 decibel practical level was permanently maintained in 197 (47 per cent).

The author reports the results of an inquiry concerning the improvement from the patient's point of view. Among 623 patients operated on, 82.8 per cent regarded the operation as successful in all respects, and only 10.2 per cent as a failure. Of the 516 who regarded the operation as completely successful, 303 reached the 30 decibel practical level and 71 were within 5 decibels of the practical level, while 142 had a more than 35 decibel loss for the speech frequencies. For the patient, not only the final hearing level but also the number of decibels gained is important. Most patients prefer the gain of hearing following the operation to a hearing aid. There is evidence that a successful fenestration may arrest or delay the nerve degeneration of otosclerosis in some cases, but it is too early to be certain of this.

With a meticulous aseptic technic the risks of the operation have proved to be minimal. The chief risks are those of the facial nerve

and the labyrinth. The two year hearing results of the operation may be regarded as the permanent hearing results.

**Shambaugh, G. E., Jr.** Fenestration Operation for Otosclerosis, *Minnesota Med.* **30:** 1249, 1947.

The author discusses briefly, for general practitioners, the principle of the fenestration operation. Each patient is classified according to bone conduction hearing tests.

**Sheridan, M. R.** Otosclerosis, *M. Press* **217:** 56, 1947.

This is a short review of the pathologic aspects and the treatment for general practitioners.

**Simpson, J. F.** An Operating Microscope for the Fenestration Operation, *Proc. Roy. Soc. Med.* **40:** 320, 1947.

The author demonstrates a microscope with three sets of eye pieces permitting magnifications of 3, 7 and 10.5 diopters.

**Sourdille, M.** The Surgical Problem of Otosclerosis, *Rev. de laryng.* **68:** 481, 1947.

Sourdille reviews briefly the history of the surgical treatment of otosclerosis and of the general principles of the operation. There are four main difficulties:

1. Difficulty of proper visualization of the ossicles and the labyrinth, which is overcome by the use of magnifying glasses (Gullstrand-Lupe and Zeiss binocular microscope).

2. Difficulty of gaining access to the middle ear and labyrinth. The author uses the retroauricular approach.

3. Suppuration of the ear operated on. This can be overcome by forming and placing a tympanomeatal flap so as to close off the middle ear, by removing the pneumatic cells completely and by introducing fibromuscular transplants into the mastoidectomy cavity.

4. Vertigo. The author stresses the importance of the preservation of the nonluxated incus for the proper transmission of sound. He prefers a fistula which is not too large and which is made over the lateral semicircular canal or over the lateral part of the ampullated end.

**Staffieri, M.** On Citelli's Tympanic Presclerosis, *Arch. ital. di otol.* **57:** 125, 1946.

The author reports 6 cases of "infantile presclerosis" in which remarkable improvement occurred under treatment with iodine. The reduction of hearing could not be explained by middle ear changes. The condition described might represent the preliminary stage of true otosclerosis, as

assumed by Citelli. This author believes that the condition is due to plastic inflammatory or dystrophic changes within the oval window niche which lead to immobilization of the stapes.

He discusses the various theories concerning the pathogenesis of otosclerosis. He thinks that the venous stasis which, according to Wittmaack, initiates the formation of the otosclerotic foci could cause the functional changes described as presclerotic by Citelli.

**Venker, J.** Some Remarks on the Fenestration Operation and What Leads to the Results, Thesis, Amsterdam, 1947; Lempert Operation in Therapy of Otosclerosis, *Nederl. tijdschr. v. geneesk.* **91:** 303, 1947.

The author uses the retroauricular approach and forms the flap according to the method of Lempert and the fistula according to the method of Shambaugh.

The results obtained with the operation in 12 cases are reviewed, and the improvement of the hearing of the ear not operated on is demonstrated. This is explained with the theory of Gray concerning otosclerosis. The open fistula allows a greater volume of sound to penetrate into the cochlea, so that the stimulation of the vasomotor system becomes more intense. This unilateral stimulus exerts its effect on both ears, owing to the fact that the sympathetic fibers of both originate in plexuses around Willis' circulus arteriosus. The disappearance of the tinnitus after operation is attributed to the better blood supply. The author refutes the assumption that an increase of intralabyrinthine pressure is present in otosclerosis.

As the author, with Gray, assumes that there are disturbances of the vasomotor system in otosclerosis and that the good results of the operation are at least partly due to an improved vasomoter reflex, he suggests one should try to achieve improvement of hearing by bilateral extirpation of the stellate ganglion, as fenestration does not yield 100 per cent successful results.

A case of otosclerosis in which mastoidectomy alone was performed resulted in a considerable improvement of hearing for several weeks. This is supposed to have been due to the stimulus of the vasomotor system following trauma of the mastoid process.

**Viole, P.** The Surgical Treatment of Deafness, *Ann. West. Med. & Surg.* **1:** 25, 1947.

This is a short review of the problem for the general practitioner.

**Weersma, P.** Fenestration Operation in Otosclerosis, *Nederl. tijdschr. v. geneesk.* **91:** 856, 1947.

This is a review for general practitioners.

**De Weese, D. D.** Fenestration for Otosclerosis: Technic and Results in Eleven Cases, *Portland Clin. Bull.* **1:** 3, 1947.

The author reports cases.

**Whitaker, C. F., Jr.; Juers, A. L., and Shambaugh, G. E.** A Modified Endaural Incision with Nerve Block Anesthesia for Fenestration and Mastoidectomy, *Arch. Otolaryng.* **45:** 662 (June) 1947.

The authors describe a modified incision which affords the following advantages: (1) a shorter postoperative course for complete healing; (2) less tendency toward atresia of the meatus; (3) less deformity.

The incision is made in two parts: The first part is started on the superior wall of the external auditory canal (12 o'clock) at the junction of the bony and the cartilaginous portions of the canal. It is extended posteriorly around the canal to the inferior wall (6 o'clock), care being taken to keep the incision at the same level of the canal. At this point the blade is directed outward and the skin cut about 0.5 cm. laterally toward the incisura. The periosteum is then divided along the posterior wall of the bony part of the canal by arclike sweeps of the knife point.

The second part of the incision is started at a right angle to the first part, on the superior wall of the canal (12 o'clock). It is first outlined with a knife, to avoid a jagged edge, by incising through the epidermis into the dermis. This incision extends out of the canal, between the tragus and the anterior crus of the helix, about 1.5 cm. along the anterior edge of the cartilage of the pinna. The incision is continued deeper, and the periosteum is divided. The temporal fascia, when encountered, is incised. If the temporal muscle is low, it is freed from its fascial sheath and is pushed upward away from the field. The periosteum is then elevated posteriorly, superiorly and inferiorly, over the mastoid process, sufficiently to provide adequate exposure. The root of the zygoma is exposed and a self-retaining retractor inserted.

After the operation has been completed, two sutures are placed in the superior part of the incision anterior to the helix. The posterior edge of the incision is tucked under the packing into the meatus.

Block anesthesia is obtained with dibucaine hydrochloride (nupercaine hydrochloride®) (1:1,500) plus 0.5 cc. of epinephrine hydrochloride 1:1,000 per 30 cc. The procedure anesthetizes in four steps all the nerves supplying the auricle (auriculotemporal), the auricular branch of the vagus nerve, the great auricular nerve and the lesser occipital nerve from the cervical plexus.

**Wilmes, M. N.** Modern Fenestration Surgery for Otosclerosis, *Hearing News* **15:** 5, 1947.

This is a discussion for laymen.

# Directory of Otolaryngologic Societies *

## INTERNATIONAL

FOURTH INTERNATIONAL CONGRESS OF OTOLARYNGOLOGY

President: Dr. V. E. Negus, London, England.
General Secretaries: Dr. F. C. W. Capps and Dr. W. A. Mill, 45 Lincoln's Inn Fields, London, W. C. 2.
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* Secretaries of societies are requested to furnish the information necessary to keep this list up to date.

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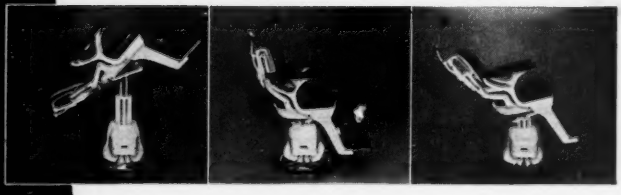

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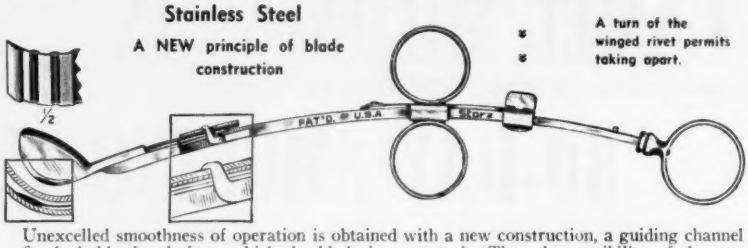


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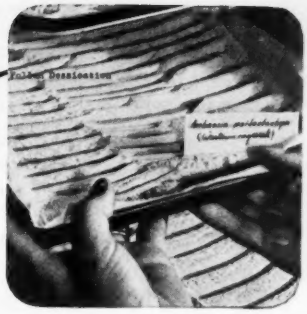

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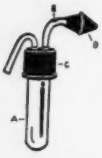

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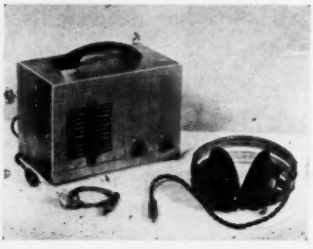

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